DRDC Toronto CR 2009-036

Counter-IED PPE Horizon 0
Phase 1 Human Factors Trial:

Performance Evaluation of Soft Armour Personal Protective Equipment

Essai ergonomique du projet Horizon 0 d'EPI à l'épreuve des IED, phase 1

Évaluation du rendement d'un équipement de protection individuel en matériel souple

By:

Harry Angel, Chris Ste-Croix, and Andrew Morton

Human*systems*® Incorporated
111 Farquhar St., 2nd floor
Guelph, ON N1H 3N4

PWGSC Contract No.: W7711-078110/001/TOR
Call-up Nos. 8110-3 & 8110-07

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by
Defence Research and Development Canada - Toronto
1133 Sheppard Avenue West
North York, Ontario, Canada
M3M 3B9

DRDC-Toronto Scientific Authority
Captain Andrea MacEachern
416.635.2193

31 March 2008

Harry A. Angel
Human*systems* Inc

Approved by

Captain Andrea MacEachren
Scientific Authority

Approved for release by

K.M. Sutton
Chair, Document Review and Library Committee

The scientific or technical validity of this Contractor Report is entirely the responsibility of the contractor and the contents do not necessarily have the approval or endorsement of Defence R&D Canada.

Abstract

The nature of the threat from Improvised Explosive Devices (IED) has changed the pattern and probability of injury for both mounted and dismounted personnel. The aim of the Horizon 0 Phase 1 and Phase 1a trials was to investigate the impact of various soft armour options on soldier mobility. The trials considered soldier task performance as well as soldier acceptance and comfort. The soft armour options varied in stiffness/flexibility, weight, bulk, and protection levels. Phase 1 was a five-day trial with twenty reserve soldiers and Phase 1a was a two day trial with eleven reserve soldiers. Participants undertook a battery of human factors tests while wearing test conditions in a repeated measures design. Fit, Range of Motion (ROM), discrete mobility, and compatibility test stands were conducted followed by dynamic assessments of mobility and agility. Data collection included questionnaires, focus groups, compatibility scores, performance measures, and Human Factors (HF) observer assessments. Test conditions used the Modular Tactical Body Armour System (MTBAS) armour carrier design, with modular add-on groin, neck, throat, and brassard protection.

In general all conditions were in the acceptable range (greater than 4), with the exception of condition A from Phase 1a and condition $N_{initial}$ in Phase 1. It appears that bulk is a more detrimental factor to soldier acceptance than stiffness. Areal density has moderate predictive value of soldier acceptance of soft armour; however, there seems to be another factor not accounted for in measures of areal density influencing soldier acceptance as strongly as areal density. By improving the stiffness, weight, and bulk of the armour in key areas around the shoulders and waist, and in the accessory protection, the acceptability of the armour fill pack N went from clearly unacceptable to clearly acceptable. The different armour cut and carrier design of the MTBAS system did not adversely impact the results. Limitations of findings are discussed, including participants, sample size, experimental conditions, limited exposure, and testing. General and Phase 2 user trial recommendations are provided.

Résumé

Par sa nature, la menace que posent les dispositifs explosifs de circonstance (IED pour *improvised explosive devices*) a modifié le type de blessure, et la probabilité de subir une blessure, auxquels s'exposent les militaires à pied ou à bord de véhicules. Les essais de phase 1 et de phase 1a du projet Horizon 0 avaient pour objet de scruter les effets de différentes options de blindage souple sur la mobilité des militaires, en tenant compte de leur rendement dans l'accomplissement de leurs tâches, de leur degré d'acceptation de l'équipement de protection individuel (EPI) et de leur confort. Les options de blindage souple comptaient différents degrés de rigidité/souplesse, de poids, de volume et de protection. La phase 1 a consisté en un essai de cinq jours mettant à contribution vingt réservistes et la phase 1a, en un essai de deux jours faisant appel à onze réservistes. Les participants, munis de divers EPI, ont subi une batterie de tests d'ergonomie observant une formule de répétition des mesures. Des bancs d'essai sur l'ajustement, l'amplitude de mouvement, la liberté de mouvement et la compatibilité ont été mis en œuvre et suivis d'évaluations dynamiques de la mobilité et de l'agilité. La cueillette de données s'est faite au moyen de questionnaires, de groupes de discussion, de notations de la compatibilité, de mesures du rendement et d'évaluations produites par des observateurs en ergonomie. Les conditions d'essai ont eu recours au concept de protection que constitue le Système de gilet pare-balles tactique modulaire (SGPBTM), avec protections modulaires amovibles pour l'aine, le cou, la gorge et les bras.

Toutes les conditions, globalement, se sont situées dans la plage acceptable (au-dessus de 4), sauf dans le cas de la condition A de la phase 1a et de la condition $N_{initiale}$ de la phase 1. Il semble que le volume pose davantage problème aux militaires que la rigidité. Il est modérément aisé, à partir de la densité surfacique, de prévoir le degré d'acceptation par les militaires d'une protection souple, mais il semble exister un autre facteur, non pris en compte dans la mesure de cette densité, qui a autant d'effet sur leur acceptation. En modifiant les caractéristiques de rigidité, de poids et de volume de la protection dans les régions clés, autour des épaules et de la taille, et dans les protections accessoires amovibles, la protection N est passé de carrément inacceptable à nettement acceptable. La coupe et le concept différents du SGPBTM n'ont pas eu d'effet négatif sur les résultats. Les limites des conclusions sont abordées, notamment les participants, la taille de l'échantillon, les conditions d'expérimentation, le caractère limité de l'exposition et les essais. Il y a formulation de recommandations d'ordre général et de recommandations sur la phase 2.

Executive Summary

The nature of the threat from Improvised Explosive Devices (IED) has changed the pattern and probability of injury for both mounted and dismounted personnel. Defence Research and Development Canada (DRDC) Valcartier is working on a Counter-IED (C-IED) Personal Protective Equipment (PPE) Horizon 0 sub-project of a larger C-IED Technical Demonstration Project (TDP). DRDC Toronto Soldier Systems Integration Group will assist with developing a thorough understanding of the physiological, biomechanical, task performance, and operational impact of increasing coverage and/or level of protection of soldiers.

The aim of the Horizon 0 Phase 1 and Phase 1a trials was to investigate the impact of various soft armour options on soldier mobility. The trials considered soldier task performance as well as soldier acceptance and comfort. The soft armour options varied in stiffness/flexibility, weight, bulk, and protection levels. The user evaluations will be conducted in two phases. Phase 1 consisted of two trials, Phase 1 and 1a, seeking to down-select torso soft armour options with the evaluation focused on soldier mobility; Phase 2 will look at extremity armour and side hard armour options with the evaluation encompassing soldier mobility and vehicle compatibility.

Phase 1 was a five-day trial undertaken at Cartier Square drill hall in Ottawa, Ontario. Twenty reserve soldiers undertook a battery of human factors tests while wearing one of the soft armour fill packs in a repeated measures design. Fit, Range of Motion (ROM), discrete mobility, and compatibility test stands were conducted followed by dynamic assessments of mobility and agility. Data collection included questionnaires, focus groups, compatibility scores, performance measures, and Human Factors (HF) observer assessments. Test conditions used the Modular Tactical Body Armour System (MTBAS) armour carrier design, with modular add-on groin, neck, throat, and brassard protection. A control condition using the current in-service Fragmentation Protection Vest (FPV) was used as a baseline.

Phase 1 tested conditions B, C, E, FPV, G, and $N_{initial}$. In general, conditions B, C, E, FPV, and G were acceptable in participant's subjective ratings while condition $N_{initial}$ was found to be unacceptable. In terms of objective measures, there were no significant differences between any of the conditions. Condition $N_{initial}$ (made up of two layers, N1 and N3) was found to be unacceptable for ROM, mobility, bulk, weight, flexibility, comfort, compatibility, and overall ratings. Identifying differences between conditions B, C, E, FPV, and G is more difficult. No differences were found between these conditions in objective measures or in most subjective measures. The focus group sessions revealed that condition C, while still acceptable, is less preferred to the other conditions. Overall data suggests that condition G also showed trends towards being less acceptable than other conditions, though not to significant levels. This leaves conditions B, E, and FPV as the most preferred conditions from Phase 1.

Phase 1a was a two day trial undertaken at the Royal Highland Fusiliers of Canada armoury in Cambridge, Ontario. Eleven reserve soldiers undertook a battery of human factors tests while wearing PPE variations in a repeated measures design. Static fit, ROM, discrete mobility, and compatibility test stands were conducted followed by dynamic assessments of mobility and agility. Data collection included questionnaires, focus groups, compatibility scores, performance measures, and HF observer assessments. Upon completion of testing all of the soft armour conditions all participants took part in a guided focus group discussion. The conditions for Phase 1a were selected based on the fill packs that were unavailable during Phase 1, a revised type N_{final} fill pack,

and reference conditions to the Phase 1 results (conditions B and G). Fill pack N3 was re-cut such that it covered approximately eighty percent of the torso area covered by N1; types N1 and N3 were then repackaged together. Furthermore only N1 was used for the brassard, groin, and throat to allow for greater mobility.

Phase 1a tested conditions A, B, D, G, and N_{final}. In general, conditions B, D, and G were acceptable in participant's subjective ratings while condition A was found to be unacceptable. Condition A was found to be unacceptable for ROM, mobility, bulk, weight, flexibility, comfort, compatibility, and overall ratings.

In general all conditions were in the acceptable range (greater than 4), with the exception of condition A from Phase 1a and condition $N_{initial}$ in Phase 1. It appears that bulk is a more detrimental factor to soldier acceptance than stiffness. Between weight and stiffness, there may be slight advantages of a heavier but more flexible material. Areal density has moderate predictive value of soldier acceptance of soft armour; however, there seems to be another factor not accounted for in measures of areal density influencing soldier acceptance as strongly as areal density. By improving the stiffness, weight, and bulk of the armour in key areas around the shoulders and waist, and in the accessory protection, the acceptability of the armour fill pack N went from clearly unacceptable to clearly acceptable. Condition $N_{initial}$ went from the least acceptable system in all evaluation criteria in Phase 1 to among the most acceptable system in Phase 1a with condition N_{final}. This evidence supports the validation of the novel concept armour cut. The inclusion of the FPV in Phase 1 as a control condition served to ensure that the different armour cut and carrier design of the MTBAS system did not adversely impact the results. In general, performance of conditions tested using the MTBAS carrier (B, C, E, G, N_{final}) compared well to the FPV condition. Limitations of findings are discussed, including participants, sample size, experimental conditions, limited exposure, and testing.

As the C-IED PPE Horizon 0 moves to Phase 2 of user trials, the emphasis will shift to extremity soft armour and rigid armour. The project will need to choose a soft armour material for the torso that balances soldier acceptance and protection levels. While condition E was the most preferred armour type for a torso system, in re-testing other soft armour materials for the extremities it is important not to create the unrealistic situation whereby greater protection is offered on the extremities than on the torso. With this trade-off in mind, condition B appears to be the optimal choice of the conditions tested for torso armour to maximize both soldier acceptance and protection. Further general and Phase 2 recommendations are provided.

Sommaire

Par sa nature, la menace que posent les dispositifs explosifs de circonstance (IED pour *improvised explosive devices*) a modifié le type de blessure, et la probabilité de subir une blessure, auxquels s'exposent les militaires à pied ou à bord de véhicules. Recherche et développement pour la défense Canada (RDDC) Valcartier travaille à un sous-projet d'équipement de protection individuel (EPI) à l'épreuve des IED (C-IED), Horizon 0, qui s'inscrit dans le plus vaste Programme de démonstration de technologie (PDT) de C-IED. Le groupe de l'intégration soldat-systèmes de RDDC Toronto contribue à acquérir une compréhension rigoureuse de l'impact physiologique, biomécanique, opérationnel et sur l'exécution des tâches qu'aurait l'augmentation de la couverture ou du niveau de protection des militaires.

Les essais des phases 1 et 1a du projet Horizon 0 ont eu pour objet de scruter les effets de différentes options de protection sur la mobilité du soldat. Ces essais ont porté sur l'exécution des tâches par les soldats ainsi que sur leur degré d'acceptation et de confort. Les options de protection souple se différenciaient les unes des autres quant à leur degré de rigidité/souplesse, de poids, de volume et de protection. Les évaluations par les utilisateurs se sont déroulées en deux phases. La phase 1 a compté deux essais, soit les phases 1 et 1a, qui visaient à choisir par élimination des options de protection souple du torse au moyen de critères de mobilité. La phase 2 portera sur la protection des extrémités et sur des options de protection rigide des côtés, l'évaluation englobant la mobilité du militaire et la compatibilité de la protection avec le véhicule dans lequel le militaire prend place.

La phase 1 a consisté en un essai de cinq jours mené au manège militaire de la place Cartier, à Ottawa, en Ontario, au cours duquel vingt réservistes se sont prêtés à une batterie de tests d'ergonomie alors qu'ils portaient des protections souples; l'essai s'est fait selon la formule de répétition des mesures. Des bancs d'essai sur l'ajustement, l'amplitude de mouvement, la liberté de mouvement et la compatibilité ont été réalisés, suivis d'évaluations dynamiques de la mobilité et de l'agilité. La cueillette de données s'est faite au moyen de questionnaires, de groupes de discussion, de notations de la compatibilité, de mesures du rendement et d'évaluations réalisées par des observateurs de l'ergonomie. L'essai a eu recours au concept de Système de gilet pare-balles tactique modulaire (SGPBTM), avec protection amovible de l'aine, du cou, de la gorge et des bras. Un critère de contrôle mené à l'aide de la veste pare-éclats (FPV pour *fragmentation protection vest*) actuellement en usage a servi de base de comparaison.

Dans le cadre de la phase 1, les conditions B, C, E, FPV, G, et $N_{initiale}$ ont été testées. D'une façon générale, les conditions B, C, E, FPV et G ont été acceptables, selon les notations subjectives des participants, tandis que la $N_{initiale}$ a été jugée inacceptable. Les mesures objectives n'ont pas révélé de grande différence entre les conditions. La condition $N_{initiale}$ (formée de deux couches, la N1 et la N3) a été jugée inacceptable au chapitre de l'amplitude de mouvement, de la mobilité, du volume, du poids, de la souplesse, du confort, de la compatibilité et de l'ensemble de la notation. Il est plus difficile de discerner les différences entre les conditions B, C, E, FPV et G. Aucune différence n'a été constatée entre ces conditions lors de mesures objectives ou de la plupart des mesures subjectives. Les séances du groupe de discussion ont permis de constater que la condition C, tout en demeurant acceptable, était la moins aimée. Les données d'ensemble mènent à croire que la condition G a aussi eu tendance à être moins acceptable que les autres conditions, mais pas dans une grande mesure. Les conditions restantes B, E et FPV ont donc été les préférées de la phase 1.

La phase 1a a consisté en un essai de deux jours réalisé au manège militaire des Royal Highland Fusiliers, à Cambridge, en Ontario. Onze réservistes se sont prêtés à une batterie de tests ergonomiques, munis de variantes de l'EPI, selon une formule de répétition des mesures. Des bancs d'évaluations statiques de l'ajustement, de l'amplitude des mouvements, de la liberté de mouvement et de la compatibilité ont eu lieu, suivit des évaluations dynamiques de la mobilité et de l'agilité. La cueillette de données a recouru à des questionnaires, à des groupes de discussion, à des notations de la compatibilité, à des mesures du rendement et à des évaluations faites par des observateurs en ergonomie. Après avoir mise à l'épreuve toutes les conditions de protection souple, tous les participants ont pris part à une discussion dirigée en groupe. Les conditions de la phase 1a ont été choisies d'après les conditions qui n'existaient pas lors de la phase 1, d'un type révisé de la condition N_{final} et de conditions de référence reliant aux résultats de la phase 1 (conditions B et G). La coupe de la protection N3 a été refaite de telle manière qu'elle couvre environ quatre-vingt pourcent de la partie du torse couvert par la protection N1; les protections de type N1 et N3 ont ensuite été combinées. Par surcroît, on n'a utilisé que la protection N1 pour les bras, l'aine et la gorge pour plus de mobilité.

Les conditions A, B, D, G et N_{finale} ont été mises à l'épreuve à la phase 1. En général, les conditions B, D, G et N_{final} ont été acceptables selon les notations subjectives des participants tandis que la condition A a été jugée inacceptable sous l'angle de l'amplitude des mouvements, de la mobilité, du volume, du poids, de la souplesse, du confort, de la compatibilité et des notations d'ensemble.

Dans l'ensemble, toutes les conditions se sont situées dans la plage acceptable (au-delà de 4), à l'exception de la condition A de la phase 1a et de la condition $N_{initiale}$ de la phase 1. Il apparaît que le volume nuit davantage à l'acceptation par les militaires que la rigidité. Entre le poids et la rigidité, un matériel lourd mais souple semble avoir un léger avantage. Il est modérément aisé, à partir de la densité surfacique, de prévoir le degré d'acceptation par les militaires d'une protection souple; mais il semble exister un autre facteur, non pris en compte dans la mesure de cette densité, qui a autant d'effet sur leur acceptation. En modifiant les caractéristiques de rigidité, de poids et de volume de la protection dans les régions clés autour des épaules et de la taille, et dans les protections accessoires amovibles, la condition N a passée de carrément inacceptable à nettement acceptable. La condition $N_{initiale}$, qui était le système le moins acceptable pour tous les critères d'évaluation lors de la phase 1, s'est classée parmi les systèmes les plus acceptables à la Phase 1a, sous la condition N_{finale}. Cette preuve appuie la validation du nouveau concept de coupe de la protection. L'inclusion de la FPV à la phase 1 en tant que condition de contrôle a permis de faire en sorte que les différents concepts de coupe et de veste tactique du SGPBTM n'aient pas d'effet négatif sur les résultats. En général, le rendement des conditions évaluées au moyen de la veste du SGPBTM (B, C, E, G, N_{finale}) s'est avantageusement comparé à celui en condition FPV. Les limites des conclusions sont abordées, notamment les éléments que sont les participants, la taille de l'échantillon, les conditions d'expérimentation, l'exposition limitée et les essais.

Maintenant que le projet Horizon 0 EPI C-IED, passe aux essais auprès d'utilisateurs de la phase 2, l'accent portera sur la protection souple des extrémités et sur la protection rigide. L'équipe du projet devra choisir un matériel de protection souple pour le torse correspondant au compromis entre l'acceptation par les militaires et les degrés de protection. Bien que la condition E se soit classée au premier rang des préférences quant au système de protection du torse, lors de la remise à l'essai d'autres matériaux de protection souple pour les extrémités, il importera de ne pas créer une situation peu plausible où les extrémités seraient mieux protégées que le torse. Sachant cela, la condition B semble constituer un choix optimal parmi les conditions mises à l'essai pour la protection du torse, maximisant l'acceptation par le militaire et la protection du militaire. Des recommandations générales supplémentaires et d'autres relatives à la phase 2 figurent dans le document.

Table of Contents

Lists of Figures and Tables

Figures

Tables

This page intentionally left blank.

1 Introduction

The nature of the threat from Improvised Explosive Devices (IED) has changed the pattern and probability of injury for both mounted and dismounted personnel. Some potential IED effects may not have been accounted for in current designs of Personal Protective Equipment (PPE). The synergistic effects of close-in blast, high density fragmentation, and larger fragments have required that armour coverage and the level of protection be revisited.

Defence Research and Development Canada (DRDC) Valcartier is working on a Counter-IED (C-IED) PPE Horizon 0 sub-project of a larger C-IED Technical Demonstration Project (TDP). They will take the lead on developing and understanding the full spectrum of IED threats to the mounted and dismounted soldier, as well as any resultant changes in vulnerability of the soldier. In order to develop PPE recommendations to overcome any change or increase in vulnerability, there needs to be a thorough understanding of the physiological, biomechanical, task performance, and operational impact of increasing coverage and/or level of protection of soldiers. DRDC Toronto Soldier Systems Integration Group has been asked to assist with evaluating these knowledge gaps. The Clothe the Soldier (CTS) plus UOR-purchased in-theatre PPE will be used as the baseline for this effort (comprising CG 634 helmet, CTS visor and ballistic eyewear, fragmentation protective vest, shoulder brassard, and ceramic plates).

Due to the iterative nature of the evaluation process for the armour options, this assessment will be done in two phases. Phase 1 consisted of a down-selection of soft armour options with the evaluation focused on soldier mobility; Phase 2 will look at extremity armour and side hard armour options with the evaluation encompassing soldier mobility and vehicle compatibility – see Table 1. Note that the Pacific Safety Products (PSP) Incorporated's Modular Tactical Body Armour System (MTBAS) was used to house the various extremity armour components.

Table 1: Horizon 0 Progressive Evaluation

Phase	Evaluation	Test Focus	Timeframe
Phase 1	Soft Armour Hard Armour (torso)	-Soldier Mobility	28 January – 1 February 2008
Phase 2	Extremity Armour Hard Armour	-Soldier Mobility -Vehicle Compatibility -Operational Task Effectiveness	May 2008

This page intentionally left blank.

2 Aim

The aim of the Horizon 0 Phase 1 and Phase 1a trials was to investigate the impact of various soft armour options on soldier mobility. The trials considered soldier task performance as well as soldier acceptance and comfort. The soft armour options varied in stiffness/flexibility, weight, bulk, and protection levels. All options utilized the same armour design pattern and MTBAS.

This page intentionally left blank.

3 Method

3.1 Overview

3.1.1 Phase 1

A five-day trial was undertaken at Cartier Square drill hall in Ottawa, Ontario. Twenty reserve force soldiers undertook a battery of human factors tests while wearing one of the soft armour fill packs in a repeated measures design. Fit, Range of Motion (ROM), discrete mobility, and compatibility test stands were conducted followed by dynamic assessments of mobility and agility. Data collection included questionnaires, focus groups, compatibility scores, performance measures, and Human Factors (HF) observer assessments.

The trial was conducted in conjunction with the second of four Soldier Integrated Headwear System (SIHS) Technology Demonstrator Project (TDP) trials. Conducting the trials simultaneously allowed the sharing of resources (participants, equipment, facilities). Due to the fact that this trial shared resources with another trial, approximately half the participants were available for two and a half days while the other half of the participants were available for the other two and a half days. Therefore, participants repeated the testing protocol outlined in Table 4 until they tested all of the different soft armour conditions. Upon completion of testing of all of the soft armour conditions all participants took part in a guided focus group discussion.

3.1.2 Phase 1a

A two day trial was undertaken at the Royal Highland Fusiliers of Canada armoury in Cambridge, Ontario. Eleven CF personnel undertook a battery of human factors tests while wearing PPE variations in a repeated measures design. Static fit, ROM, discrete mobility, and compatibility test stands were conducted followed by dynamic assessments of mobility and agility. Data collection included questionnaires, focus groups, compatibility scores, performance measures, and HF observer assessments. Upon completion of testing of all of the soft armour conditions all participants took part in a guided focus group discussion.

3.2 Armour Conditions

3.2.1 Phase 1

Six soft armour conditions were tested, as detailed in Table 2. The intent of the trial was to test a total of eight conditions; however, two of the armour conditions were not available due to material delays. As a result these two conditions, labelled A and D, could not be assessed in this trial and are indicated in Table 2 with shading. All test conditions used the MTBAS armour carrier design, with modular add-on groin, neck, throat, and brassard protection. A control condition using the current in-service Fragmentation Protection Vest (FPV) was used as a baseline. All participants were subject to each condition for an equal period of time.

Note: Condition N was not cut properly for this phase. Condition N is made up of two soft armour fill packs layered on top of one another (N1 and N3). N1 is the thinner material with N3 being

more bulky. N1 is supposed to cover all the regions while N3 is only supposed to be layered over the front and back torso, leaving the approximately 2 inches around the sides of the armour to permit movement, and only N1 for the throat, groin, and brassard. However, during Phase 1 N1 and N3 was layered over the entire coverage area and not permitting the same level of mobility that was intended. Therefore, condition N for Phase 1 will be referred to as $N_{initial}$ and condition N for Phase 1a will be referred to as N_{final}.

Table 2: Phase 1 Armour Test Conditions

System ID	Fill
A	10 plies KM2 600 + 9 plies FR10 with 1.9kg plates
B	34 plies KM2 400 with 1.9kg plates
C	19 plies Spectra Shield SA-3118 with 1.9kg plates
D	26 plies Soft Steel with 2.6kg plates
E	~26 plies KM2 400 with 2.6kg plates
G	Baseline with 2.6kg plates
$N_{initial}$	2.1 kg/m^2 KM2 400 (N1), 5.4 kg/m^2 Spectra Shield SA-3118 (N3) with 1.4 kg plates
FPV	Baseline with current armour cut with 2.6kg plates

3.2.2 Phase 1a

Five soft armour conditions were tested, as detailed in Table 3. The conditions for Phase 1a were selected based on the fill packs that were unavailable during Phase 1, a revised type N fill pack, and reference conditions to the Phase 1 results (conditions B and G). Fill pack N3 was re-cut such that it covered approximately eighty percent of the torso area covered by N1, types N1 and N3 were then repackaged together. Furthermore only N1 was used for the brassard, groin, and throat to allow for greater mobility. All test conditions used the MTBAS armour carrier design, with modular add-on groin, neck, throat, and brassard protection. All participants were subject to each condition for an equal period of time in a partially balanced order.

Table 3: Phase 1a Armour Test Conditions

System ID	Fill
A	10 plies KM2 600 + 9 plies FR10 with 1.9kg plates
B	34 plies KM2 400 with 1.9kg plates
D	26 plies Soft Steel with 2.6kg plates
G	Baseline with 2.6kg plates
N_{final}	2.1 kg/m^2 KM2 400, 5.4 kg/m^2 Spectra Shield SA-3118 with 1.4 kg plates

3.2.3 Area Coverage

Participants were inspected for torso area coverage while wearing both the FPV and the MTBAS. The inspections were used to ensure consistent coverage from the soft armour and ballistic plates.

3.3 Protocol

A progressive testing protocol was employed in both phases of the trial. The tests progressed from fit and anthropometric testing to static test stands, ROM, weapons and vehicle compatibility, and

discrete mobility tests followed by an obstacle/assault course. Table 4 describes the progressive testing organized into a single iteration of the testing protocol.

Table 4: Iteration Testing Protocol

Timeline (minutes)		Activity	Evaluations
0-10	(10)	Condition Intro	• Switch soft armour fill packs • Fit/Adjustability
10-85	(75)	Test Round-Robin -3 stands (25 minutes each)	• ROM & Equipment Compatibility • Discrete Mobility • Weapons/SATS Range (Phase 1 only)
85-105	(20)	Assault Course	• Combined obstacle/assault course
105-120	(15)	Condition Exit	• Completion of Condition Questionnaire • Return soft armour fill packs

Each participant completed this cycle for each of the armour conditions tested.

3.4 Participants

3.4.1 Phase 1

A total of twenty male participants from the Cameron Highlanders of Ottawa, the Governor General's Foot Guards, 30th Field Regiment Royal Canadian Artillery, and the Princess of Wales' Own Regiment took part in the experiment. Participants' average time in the reserve unit was approximately 4 years and three participants had operational experience.

3.4.2 Phase 1a

A total of eleven participants, ten male and one female, from the Royal Highland Fusiliers of Cambridge took part in the experiment. Participants' average time in the reserve unit was approximately 4 years and two participants had operational experience.

3.5 Measures

3.5.1 Anthropometry

Participants were measured for various anthropometric measurements. The measurements were used to size participants for the MTBAS and FPV, and to ensure the study had a representative user population.

3.5.2 Range of Motion

Torso, shoulder, and hip ROM measurements were taken for each participant with each type of soft armour condition to identify any movement restrictions.

3.5.3 Subjective Ratings

Participants gave ratings of the soft armour conditions on a variety of criteria using a systematic approach to collecting subjective perceptions. Participants gave task compatibility ratings and completed a condition exit questionnaire after each iteration throughout the trial. Using a 7-point scale, where one was '*completely unacceptable*', four was '*borderline*', and seven was '*completely acceptable*', participants rated the acceptability of the soft armour conditions – See Figure 1.

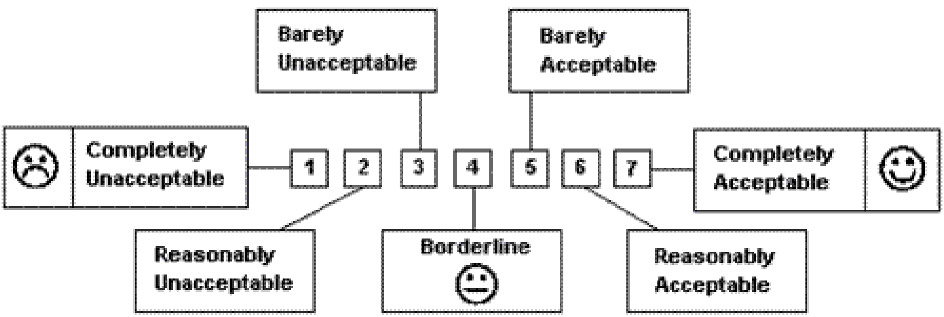


Figure 1: Acceptance Scale

In addition, participants were asked to rate both thermal and physical discomfort of the soft armour conditions. For thermal discomfort a 5-point scale was used, where one was *'neutral'*, three was *'warm'*, and five was *'very hot'*. For physical discomfort participants also gave ratings on a 5-point scale, where 1 was *'neutral'*, three was *'noticeable discomfort'*, and five was *'extreme pain'*.

All questionnaires were completed by each participant a total of six times in Phase 1 and five times in Phase 1a, once while wearing each of the different soft armour fill pack test conditions. The comparisons of the results of these questionnaires were used for the analysis.

3.5.4 Focus Group

Following the completion of the trial, participants took part in a guided focus group. Issues with each of the fill packs were discussed in an effort to gain consensus opinions of the fill packs and add context to the numerical data collected.

3.6 Procedures

Data collection focused on the following HF requirements detailed below. The order in which participants were exposed to the soft armour conditions was balanced.

- Anthropometry;
- Fit/ Coverage;
- Range of Motion;
- Weapons Compatibility/SAT Range Firing (Phase 1);
- Vehicle Compatibility (Phase 1);

- Discrete Mobility Tasks;
- Obstacle/Assault Course;
- Thermal Discomfort; and
- Physical Discomfort.

3.6.1 Anthropometry

Anthropometric measurements of the participants were taken to determine participant dimensions and ensure proper sizing of PPE. Anthropometric measurements were taken once at the commencement of the trial by trained HF observers. The following measurements were taken:

- **Weight**: The subject stood on the platform of a scale and the weight of the subject was taken to the nearest tenth of a kilogram.
- **Stature**: The vertical distance from a standing surface to the top of the head is measured with an anthropometer. The subject stands erect with the head in the Frankfort plane. The heels are together with the weight distributed equally on both feet. The shoulders and upper extremities are relaxed. The measurement is taken at the maximum point of quiet respiration.
- **Chest Circumference**: The maximum horizontal circumference of the chest at the fullest part of the breast is measured with a tape. The subject stands erect looking straight ahead. The shoulders and upper extremities are relaxed. The measurement is taken at the maximum point of quiet respiration.

3.6.2 Fit/ Coverage

At the beginning of each soft armour condition, participants inserted the soft armour fill pack into the armour carrier and fit and adjusted the armour within the carrier to ensure proper alignment of the ballistic plates. At the end of each iteration participants rated the fit of the soft armour fill packs and following the conclusion of the trial all participants rated the overall fit of the MTBAS carrier system.

3.6.3 Range of Motion

A series of ROM measurements were taken to quantify the effect of the soft armour on the soldiers' flexibility and reach. ROM measurements included the following with steps as to how the measurements were calculated:

- **Trunk Forward Flexion (Modified Wells and Dillon Sit and Reach)** – see Figure 2.
    - The subject sits with legs fully extended with the soles of the feet placed flat against the horizontal crossboard of the apparatus.
    - Both inner edges of the feet should be placed 2 cm from the scale.
    - Keeping the knees fully extended, arms evenly stretched, palms down, the subject bends and reaches forward pushing the sliding marker along the scale with their fingertips as forward as possible.
    - The position should be held for approximately 2 seconds

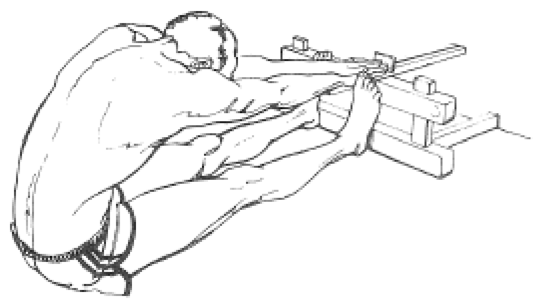


Figure 2: Modified Wells and Dillon Sit and Reach Test

- **Trunk Lateral Flexion (Standing)**
  - Place a single inclinometer at the mid level of the thoracic vertebra.
  - Instruct the participant to bend the trunk to the side as far as possible and record the inclinometer angle.
- **Arm Horizontal Plane Adduction**
  - Place the participant's dominant shoulder in 30° of flexion.
  - Have the participant flex their elbow to approximately 90° of flexion.
  - Have the forearm rotated into the mid-position between supination and pronation.
  - Have the inclinometer near the elbow and ensure that the reading is 0°.
  - Ask the participant to adduct their arm in front of their body and record the inclinometer angle.
- **Trunk Rotation**
  - Place the inclinometers on the mid level of the thoracic vertebra in the vertical position.
  - Ask the participant to maximally rotate the trunk to the side and record the angle.
- **Hip Flexion**
  - Have the participant lying on a table in the supine position with both lower extremities and the pelvis stabilized on the table.
  - To stabilize the pelvis, ask the participant to flex the opposite hip maximally to keep the lumbar spine flat.
  - Then ask the participant to maximally flex the measured hip and when the ASIS starts to move record the hip flexion angle.

3.6.4 Weapons Compatibility

Participants conducted weapons compatibility testing with a range of light infantry weapons, including: C7A1 (using SATS range in Phase 1 only), C9, C6, M72, and Carl Gustav. Compatibility testing evaluated a variety of firing postures, stock weld, check weld, sight picture, reload, and remedial action.

3.6.5 Vehicle Compatibility

In the Phase 1 trial, participants evaluated compatibility of armour conditions with the Light Utility Vehicle Wheeled (LUVW or G-Wagon), Light Support Vehicle Wheeled (LSVW), and the Medium Logistics Vehicle Wheeled (MLVW) vehicles. Participants were instructed to perform a set of drills in each vehicle to test the ease of mounting, operating, and dismounting the vehicles with the soft armour conditions. Due to the availability of vehicles, this was only completed during Phase 1. Specific evaluations included:

a) **Access/Egress:** Participants were required to rate the ease of access and egress of vehicle hatches and doors. HF observers evaluated soldiers entering and exiting vehicles for any postural, range of movement, and vehicle obstruction effects.

b) **Vehicle Operation:** Participants were required to rate the estimated ease of driving the vehicle in each condition. HF observers evaluated participants during vehicle operation for any postural, range of movement, and crew station obstruction.

c) **Turret Tasks (where applicable):** Participants were required to rate the estimated ease of performing hatch tasks in the G-wagon. HF observers evaluated participants during vehicle operation for any postural, range of movement, and crew station obstruction.

Participants were required to rate the compatibility of each of the conditions noting restrictions on movements with each of the assigned vehicles. HF observers noted instances where certain tasks could not be performed due to the stiffness, bulkiness, or incompatibility of the conditions.

3.6.6 Discrete Mobility Tasks

During each fill pack condition evaluation, participants completed a circuit of discrete mobility tasks in an attempt to gain objective performance measures to compare the various soft armour conditions. The circuit was conducted in order of the activities described below.

Vertical Leap

Participants were required to leap vertically as high as possible from a stationary, standing position with the wall to the side of the participant. With a measuring tape secured to the wall, the participant was instructed to jump as high as possible using a deep knee bend and their dominant hand to touch the wall. This was conducted two times for each participant with each soft armour condition. The highest height measured by the HF observer was used in the analysis.

Stepping Sprint

The stepping sprint is a measure of leg speed. Participants were required to step up and down a single step measuring approximately 20 cm high for a period of 30 seconds. Stepping was performed with a four pace cycle: step up with one foot, step up with second foot, step down to the ground with one foot, and step down with the second foot. Participants were required to perform

each four pace cycle as many times as possible and the total number of cycles was recorded by a HF observer.

Wall Touch

Participants were required to perform this test of upper extremity mobility for a period of 30 seconds, once with each hand. Two pieces of framing lumber were placed 2 m from each other and extended 3 m high. Targets were placed on each piece of lumber at heights of 50 cm and 175 cm from the floor. The task was to touch as many targets as possible in the selected timeframe. The subject starts with the lower right switch and then moves to the lower left switch, followed by the top right switch, and lastly the top left switch. This cycle is then repeated. A diagram of the set-up and cycle is shown below – see Figure 3.

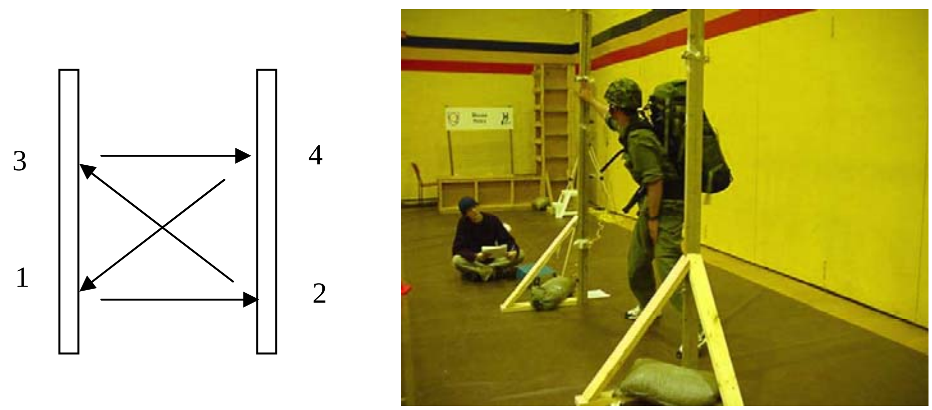


Figure 3: Wall Touch Test Setup

Agility Run

Participants were then required to complete an agility run that had a length of 25 m and a width of 5 m. Each participant began at the start in the prone position. They were then required to sprint in a zigzag manner around pylons. At each pylon they were to run on the outside of the pylon and bend over and touch the pylon with their inside hand. A diagram of the agility is shown below – see Figure 4. Each participant completed this twice with the fastest time being used for analysis.

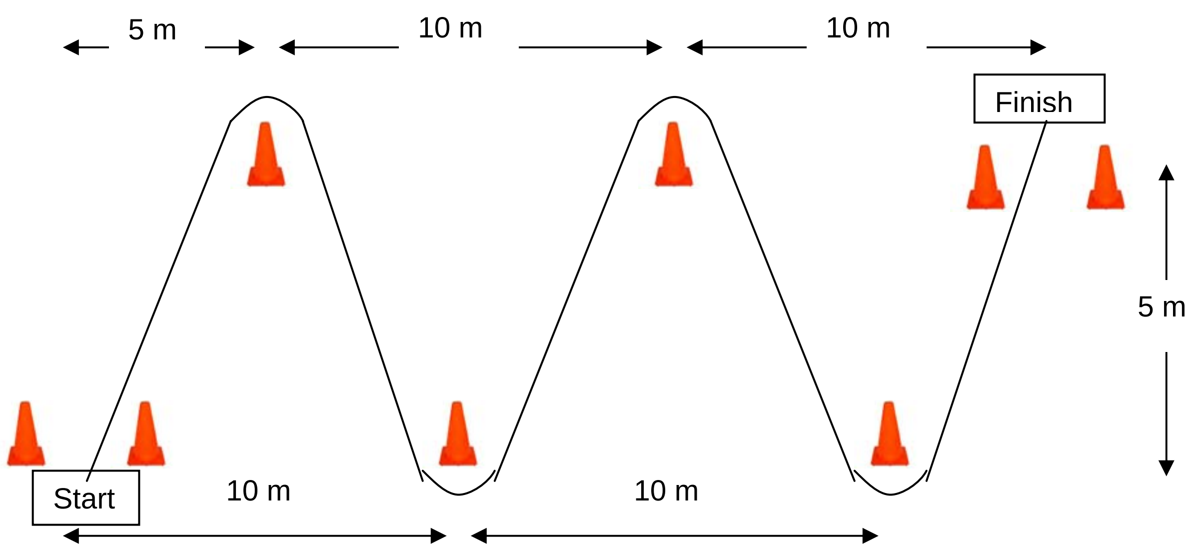


Figure 4: Agility Run Test Setup

20 m Sprint

Participants were required to complete a 20 m sprint as fast as possible from the standing position. Each participant started with a single toe on the starting line prior to starting the sprint. Each participant completed this two times with a HF observer recording the fastest time.

Grenade Toss

Participants were required to toss a tennis ball like a grenade from the prone position to a target approximately 15 m away. Participants were then required to give each soft armour condition an acceptability rating based on the 7-point scale for the grenade toss.

3.6.7 Obstacle/Assault Course

Prior to the end of each condition, each participant was required to complete an indoor obstacle/assault course using a portable obstacle course and a temporary FIBUA training site. The assault course was designed to combine dynamic mobility aspects of the obstacle course with the tactical manoeuvre aspects of a FIBUA assault. Participants moved through the assault course in small teams of two or three, moving tactically, and using fire and movement techniques. A plan of the assault course is shown below with a list of the activities – see Figure 5. The list of activities shown is for the Phase 1 assault course. The FIBUA room clearing portion of the assault course was only available during Phase 1.

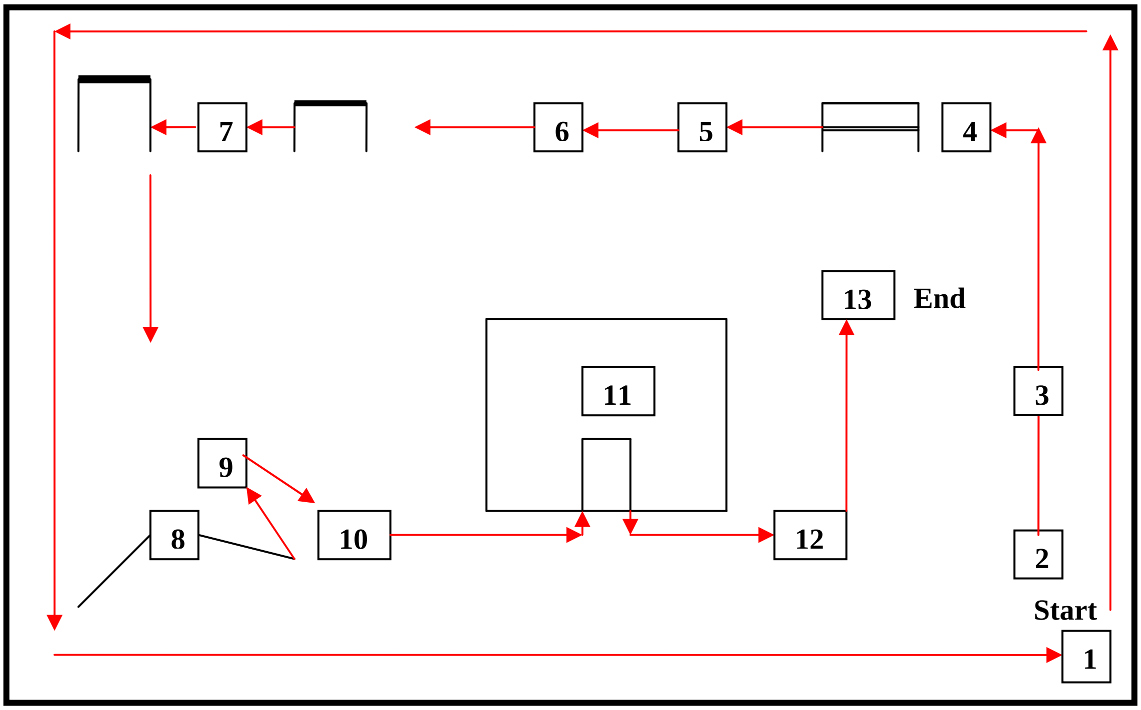


Figure 5: Assault Course Plan

1) March around Gym (x2)
2) Adopt Prone Fire Position
3) Leopard Crawl
4) Fence Climb (low-wall)
5) Combat Roll
6) Adopt Kneeling Fire Position & Evading Fire
7) Over-Under & Standing Supported Fire Position
8) Ramp
9) Boulder Hop/ Irish Stones
10) Pepper Potting / Fire Team Rushes
11) FIBUA Room Clearing (Phase 1 Only)
12) Adopt Prone Firing Position
13) Grenade Toss

At the conclusion of the assault course participants indicated their perceived level of exertion using the Borg Rating of Perceived Exertion (RPE) 6 – 20 scale.

3.6.8 User Acceptance

Participants were required to rate their overall acceptance of each condition, including their fit, stability, range of motion, overall compatibility, and mobility using the standard 7-point scale in an exit questionnaire.

3.6.9 Physical Comfort

At the conclusion of each condition participants were required to complete a physical comfort questionnaire. This questionnaire was comprised of drawings of the front of the torso. Participants were required to indicate the body location and rate the extent of physical discomfort using the five point rating scale. Discomfort could include, but is not limited to, contact irritation or pressure points. HF observers investigated any reports of physical discomfort through photographs and interviews with affected participants.

3.6.10 Thermal Comfort

At the conclusion of each condition participants were also required to complete a thermal comfort questionnaire. This questionnaire was comprised of drawings of the front of the torso. Participants were required to indicate the body location and rate the extent of thermal discomfort using the five point rating scale. Discomfort could include, but is not limited to, hot spots or ventilation. HF observers investigated any reports of thermal discomfort through photographs and interviews with affected participants

3.7 Statistical Plan

The objective results of this evaluation were analyzed using parametric Analysis of Variance (ANOVA) methods. Subjective results were analyzed using non-parametric methods. These methods included: Friedman Analysis of Variance (ANOVA) & Kendall Coefficient of Concordance analysis, and Chi-Square tests. Differences were identified at $p < 0.05$. Note that there was some variation in sample size from missing data points for questionnaires as some participants did not complete questionnaires fully due to lack of experience or forgetting to answer a question. In instances where greater than 10% of answers were not included the question was withdrawn from statistical analysis. If the missing answers were less than 10% of the participants then those participants were withdrawn from the analysis. Note that Friedman post hoc analyses are more conservative than Friedman non-parametric ANOVAs and as a result some significant main effect results cannot be further differentiated. The statistical plan was as follows:

Table 5: Statistical Plan

Data Source	Data Type	Analysis Type
Range Of Motion	ROM Measurement	Repeated measures ANOVA for each ROM measurement
Discrete Mobility	Performance Measurement	Repeated measures ANOVA for each ROM measurement
Weapons Compatibility Assessments	Subjective compatibility assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each assessment
Vehicle Compatibility Assessments	Subjective compatibility assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each assessment
Condition Exit Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question.
Physical Discomfort Questionnaire	Subjective assessment by participant	Mean rating for each region
Thermal Discomfort Questionnaire	Subjective assessment by participant	Mean rating for each region
CALM	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each question.
Final Exit Questionnaire	Subjective assessment by participant	Friedman ANOVA and Kendall Coefficient of Concordance for each task question.

4 Results

Results are presented by phase. Mean and standard deviation (SD) are presented for objective measures and subjective ratings data. Where appropriate, repeated measures Analysis of Variance (ANOVA) analyses were conducted on objective performance data and significant findings are presented. Subjective rating data has been analyzed with Friedman non-parametric ANOVAs and where significant differences were found, appropriate Friedman post hoc analyses were used to identify differences between conditions. Complete details of statistical analyses can be found in Annex B.

4.1 Phase 1 Results

4.1.1 Anthropometric Measurements

The main anthropometric measures that were taken were stature and chest circumference. The average stature of the participants was 181.42 cm with a minimum of 170.5 cm that coincides with the 20th percentile male, according to the Canadian Forces Land Forces Anthropometric Survey in 1997 (Chamberland, Carrier, Forest, & Hachez, 1997), and a maximum stature of 194.5 cm, which coincides with greater than the 99th percentile male. The average chest circumference was 100.66 cm with a minimum of 87 cm, which coincides with the 3rd percentile male, and a maximum chest circumference of 114.7 cm, which coincides with the 95th percentile male – see Table 6. The anthropometric measurements were compared to the male population due to the fact that all participants in this trial were male. Even though, all participants were previously measured and fitted to a medium-regular helmet for SIHS testing, the participants also represented a large range of the population based on their other anthropometric measurements.

Table 6: Anthropometric Measurements of Participants

	Mean (SD)	Min (percentile male)	Max (percentile male)
Stature(cm)	181.42 (6.53)	170.50 (20%)	194.50 (>99%)
Chest Circumference (cm)	100.66 (8.26)	87.00 (3%)	114.70 (95%)

4.1.2 Range of Motion

All participants were measured for a series of joint ranges of motion while wearing each the FPV and the soft armour conditions with the MTBAS carrier. A repeated measures ANOVA was performed for each measure to identify significant measures. The analysis shows significant differences between the conditions for all of the ranges of motion that were measured. Condition $N_{initial}$ performed the worst in every condition. In terms of the best performing conditions, the FPV, B, and E tended to perform favourably for the trunk and shoulder ranges of motion. Averages are shown below in Table 7 with the standard deviations in parentheses.

Table 7: Ranges of Motion by Condition

Factor (n=16)	B	C	E	FPV	G	$N_{initial}$
Trunk Forward Flexion (cm) p-value<0.00000	48.89 (6.39)	48.05 (6.12)	49.39 (6.49)	49.28 (6.85)	47.09 (7.19)	44.09 (8.18)
Trunk Lateral Flexion(°) p-value<0.00000	132.73 (7.44)	129.94 (6.92)	133.52 (6.11)	133.78 (7.85)	129.79 (6.01)	128.11 (6.72)
Shoulder Adduction(°) p-value<0.03366	116.50 (7.86)	115.91 (5.47)	119.32 (5.57)	116.00 (5.91)	117.37 (5.02)	114.66 (5.55)
Trunk Rotation(°) p-value<0.03695	40.67 (16.69)	36.94 (13.59)	41.50 (16.19)	43.08 (16.97)	38.79 (15.55)	34.50 (15.44)
Hip Flexion(°) p-value<0.00674	79.03 (9.80)	77.91 (10.75)	78.50 (9.57)	73.94 (10.19)	77.63 (9.67)	80.00 (9.39)

Note: Hip flexion angles were measured between the trunk and the thigh while the subject lay supine. Therefore, a smaller measured angle refers to a greater amount of hip flexion.

- Trunk Forward Flexion – Condition $N_{initial}$ was significantly worse than all other conditions
- Trunk Lateral Flexion – Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV.
- Shoulder Adduction – Condition $N_{initial}$ was significantly worse than condition E.
- Trunk Rotation – Condition $N_{initial}$ was significantly worse than the FPV.
- Hip Flexion – Conditions $N_{initial}$ and B were significantly worse than the FPV.

4.1.3 Weapons Compatibility

All participants evaluated the compatibility of a selection of weapons with each soft armour condition. Each participant was guided through normal weapons handling drills and gave the HF observer a subjective rating based on the 7-point acceptability scale. Average ratings are shown below in Table 8 with standard deviations in parentheses. For conditions B, C, E, FPV and G most of the scores were between 'barely acceptable' and 'completely acceptable'. However, condition $N_{initial}$ was found to be unacceptable for the C7A1 in the prone, kneeling, and standing positions, and was 'borderline' for the C6. Friedman non-parametric ANOVA was performed on the data along with the appropriate Friedman post hoc analyses to identify differences between conditions. All weapons that were found to have significant differences among the conditions are shaded with more detailed analyses of the differences given below. Areas that were found to be unacceptable are italicized.

Table 8: Weapons Compatibility by Condition

Factor (n=16)	B	C	E	FPV	G	$N_{initial}$
C7A1 Prone (p<.00000)	6.12 (0.79)	5.44 (0.81)	6.58 (0.59)	6.31 (0.79)	6.33 (0.69)	*3.67 (1.68)*
C7A1 Kneeling (p<.00000)	5.18 (0.99)	4.75 (1.39)	5.64 (1.22)	5.69 (1.01)	5.61 (0.92)	*3.11 (1.64)*
C7A1 Standing (p<.00000)	5.11 (0.91)	4.56 (0.96)	5.86 (1.09)	5.88 (0.89)	5.50 (0.99)	*3.28 (1.64)*
C9 (p<.00000)	6.17 (0.74)	6.00 (1.03)	6.64 (0.58)	6.44 (0.73)	6.33 (0.84)	4.11 (1.84)
C6 (p<.00000)	6.12 (1.07)	5.75 (1.29)	6.43 (0.59)	6.56 (0.73)	6.33 (0.97)	4.00 (1.71)
M72 (p<.00054)	6.45 (0.67)	6.25 (0.86)	6.54 (0.68)	6.69 (0.48)	6.50 (0.62)	5.83 (0.99)
Carl Gustav (p<.01966)	6.45 (0.58)	6.44 (1.03)	6.59 (0.68)	6.38 (0.81)	6.61 (0.61)	5.89 (1.41)
9mm Pistol (p<.02298)	6.42 (0.80)	6.16 (1.09)	6.54 (0.76)	6.00 (1.27)	6.56 (0.78)	6.20 (1.04)

- C7A1 Prone: Condition $N_{initial}$ performed significantly worse than conditions B, E, FPV, and G. Condition C performed significantly worse than condition E.
- C7A1 Kneeling: Condition $N_{initial}$ performed significantly worse than conditions B, E, FPV, and G.
- C7A1 Standing: Condition $N_{initial}$ performed significantly worse than conditions B, E, FPV, and G. Condition C performed significantly worse than condition E and the FPV.
- C9: Condition $N_{initial}$ performed significantly worse than conditions B, E, FPV, and G.
- C6: Condition $N_{initial}$ performed significantly worse than conditions B, E, FPV, and G.
- M72: Condition $N_{initial}$ performed significantly worse than condition E and the FPV.

4.1.4 Vehicle Compatibility

All participants were asked to assess the compatibility of the conditions with a G-wagon, LSVW, and MLVW. The participants were asked to perform all tasks that are typical within a vehicle on a convoy. Once completed, each participant rated the compatibility of the condition while performing those tasks. The vehicle compatibility ratings are shown in Table 9 with standard deviations in parentheses. All conditions had ratings that were above 'borderline', while conditions G, E, B, and FPV had ratings for all vehicles between 'reasonably acceptable' and 'completely acceptable'. Condition C had ratings between 'barely acceptable' to 'reasonably acceptable', and condition $N_{initial}$ had ratings between 'borderline' and 'barely acceptable'. Friedman's non-parametric ANOVA was performed on the data for each vehicle along with an appropriate Friedman post hoc analysis to identify differences between conditions. Where significant differences were identified a description of the differences are provided.

Table 9: Vehicle Compatibility by Condition

Factor (n=15)	B	C	E	FPV	G	$N_{initial}$
G-Wagon (p<.00000)	6.74 (0.85)	5.92 (1.18)	6.72 (0.44)	6.59 (0.48)	6.50 (0.83)	4.35 (1.48)
LSVW (p<.00000)	6.33 (1.10)	5.71 (1.22)	6.44 (0.81)	6.53 (0.59)	6.17 (1.01)	4.76 (1.75)
MLVW (p<.00000)	6.40 (1.00)	6.00 (1.00)	6.51 (0.81)	6.65 (0.46)	6.22 (1.08)	4.76 (1.62)

- G-wagon: Condition $N_{initial}$ was found to be significantly worse than conditions B, E, FPV, and G. Condition C was also found to be significantly worse than condition B.
- LSVW: Condition $N_{initial}$ was found to be significantly worse than conditions B, E, FPV, and G. Condition C was also found to be significantly worse than the FPV.
- MLVW: Condition $N_{initial}$ was found to be significantly worse than conditions B, E, FPV, and G.

4.1.5 Discrete Mobility Tasks

All participants completed a series of discrete mobility tasks wearing each of the soft armour conditions. More detailed descriptions of the results of each task are described below. A repeated measures ANOVA was conducted for each task to identify significant differences. Where significant differences were observed, p-values are provided.

Vertical Leap

The average vertical leap measurements ranged from 111.29 cm with condition $N_{initial}$ to 116.00 cm with condition B. All measurements are shown in Table 10 with standard deviations in parentheses. Significant differences were observed between conditions.

Stepping Sprint

The number of step cycles in 30 seconds ranged from 34.76 cycles with condition G to 36.50 cycles with condition E – see Table 10. This is a difference of approximately 1.5 cycles. With standard deviation ranging from 4 – 5 cycles there were no significant differences between the conditions during the stepping sprint. It can be assumed that the conditions did not cause a measureable difference to soldier performance during the stepping sprint.

Wall Touch

The number of touches in 30 seconds ranged from 42.76 touches with condition $N_{initial}$ to 44.50 touches with condition E – see Table 10. It was assumed that the FPV should perform the best since it does not incorporate an upper arm brassard system that could restrict movement of the upper arm. However, this benefit did not translate noticeably to performance since the gap between the FPV and condition $N_{initial}$ was only 2 touches. Armour condition did not have any effect on performance during the wall touch task and the inclusion of a shoulder brassard did not negatively affect performance.

Agility Run

The time to complete the agility course ranged from 12.77 seconds with condition B to 13.37 seconds with condition $N_{initial}$ – see Table 10. The difference between the best and worst performing conditions was less than one second. This task forced the individuals to bend over at the waist to touch each pylon that they passed. Significant differences were observed between conditions.

20 m Sprint

The time to complete the 20 m sprint ranged from 4.21 seconds with the FPV to 4.42 seconds for condition $N_{initial}$ – see Table 10. The difference between the best and worst performing conditions was less than half a second. Significant differences were observed between conditions.

Grenade Toss

Each participant completed a modified grenade toss (tennis ball) from the prone position to a target approximately 15 m away. After they completed the task, each participant provided a subjective rating to the HF observer based on the 7-point acceptability scale. Condition E had a score that ranged from 'reasonably acceptable' to 'completely acceptable', while conditions B, C, FPV and G had scores ranging from 'barely acceptable' to 'reasonably acceptable', and finally, condition $N_{initial}$ scored between 'borderline' and 'barely acceptable' – see Table 10.

The repeated measures ANOVA identified that there were significant differences between the conditions for certain of the discrete mobility tasks. A Friedman non-parametric ANOVA identified differences between the conditions during these tasks. The complete results are described below Table 10.

Table 10: Discrete Mobility Scores by Condition

Factor (n=15)	B	C	E	FPV	G	$N_{initial}$
Vertical Leap (cm) p-value<0.00061	116.00 (13.32)	113.29 (12.62)	115.50 (11.71)	115.64 (10.20)	115.06 (10.80)	111.29 (13.27)
Agility Run (seconds) p-value<0.00775	12.77 (1.02)	13.08 (0.76)	13.06 (1.00)	12.70 (0.98)	12.95 (0.88)	13.37 (1.10)
Stepping Sprint (cycles) p-value< 0.25264	35.41 (5.29)	34.88 (5.15)	36.50 (4.36)	36.06 (4.53)	34.76 (4.41)	34.88 (4.43)
20 m Sprint (seconds) p-value<0.00252	4.25 (0.22)	4.31 (0.27)	4.37 (0.25)	4.21 (0.23)	4.24 (0.29)	4.42 (0.26)
Wall Touches (touches) p-value<0.17704	44.00 (5.17)	43.50 (4.53)	44.50 (5.71)	44.38 (5.35)	43.17 (4.73)	42.76 (6.00)
Grenade Toss (p<.00000) (n=17)	5.94 (0.85)	5.19 (1.05)	6.19 (0.54)	5.94 (0.87)	5.76 (0.75)	4.64 (1.22)

- Vertical Leap – Condition $N_{initial}$ was significantly worse than conditions B, E, G, and the FPV.
- Agility Run – Condition $N_{initial}$ was significantly worse than condition B and the FPV.
- 20m Sprint – Condition $N_{initial}$ was significantly worse than the FPV and condition G.
- Grenade Toss: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. (Critical Value= 1.7365)

4.1.6 Condition Exit Questionnaire

At the conclusion of each condition, following an assault course, each participant completed a condition exit questionnaire. The results are shown below in Table 11. The first question asked the participant to rate their perceived level of exertion based on the Borg RPE scale, which is an ordinal scale with verbal anchors to standardize comparisons across individuals and tasks. Ratings ranged from Condition B and the FPV score of 11.83 which coincides with a 'light' score to the condition $N_{initial}$ score of 15.33 which coincides with hard (heavy). Significant differences are detailed below Table 11.

For the remaining items of the questionnaire, Condition B had scores that ranged from 'barely acceptable' to 'completely acceptable' with the majority of the ratings being between 'reasonably acceptable' to 'completely acceptable'. Condition B did not have any instances where it was found to be unacceptable. Condition B was rated acceptable by at least 80% of participants for all items.

Condition C had scores ranging from 'borderline' to 'reasonably acceptable' with the majority of the scores falling between 'barely acceptable' to 'reasonably acceptable'. Condition C was rated acceptable by at least 80% of participants for all items

Condition E had scores that ranged from 'barely acceptable' to 'completely acceptable' with the majority of the ratings being between 'reasonably acceptable' to 'completely acceptable'. Condition E was rated acceptable by at least 80% of participants for all items.

The FPV had scores that ranged from 'barely acceptable' to 'completely acceptable' with the majority of the ratings being between 'reasonably acceptable' to 'completely acceptable'. The FPV was rated acceptable by at least 80% of participants for all items.

Condition G had scores that ranged from ‘barely acceptable’ to ‘completely acceptable’ with the majority of the ratings being below ‘reasonably acceptable’. Condition G was rated acceptable by at least 80% of participants for all items

Condition $N_{initial}$ had scores that ranged from ‘barely unacceptable’ to ‘reasonably acceptable’ with the majority of the scores being between ‘barely unacceptable’ and ‘barely acceptable’. Condition $N_{initial}$ was found to be unacceptable for overall weight, flexibility/stiffness, thickness, bulk, ROM, ventilation, and compatibility with the C7.

The data was analyzed using Friedman non-parametric ANOVAs and appropriate Friedman post hoc analyses. P-values are given next to the criteria with a detailed description of the differences between conditions given below Table 11. Criteria which showed significant differences are highlighted and areas that were found to be unacceptable are italicized.

Table 11: Condition Exit Results

Factor (n=17)	B	C	E	FPV	G	$N_{initial}$
Perceived Exertion (p<.00000)	11.83 (2.53)	13.12 (2.78)	12.37 (2.39)	11.83 (2.66)	12.44 (2.43)	15.33 (2.33)
Fit (p<.00331)	5.89 (0.96)	5.71 (0.92)	6.26 (0.73)	6.17 (0.71)	6.00 (0.77)	5.17 (1.58)
Ease of Assembly (p<.00000)	5.78 (1.00)	5.53 (0.62)	5.89 (1.20)	6.61 (0.70)	5.94 (0.87)	5.11 (1.37)
Stability (p<.00003)	6.06 (1.00)	5.94 (0.66)	6.37 (0.76)	6.45 (0.70)	6.11 (0.67)	5.34 (1.14)
Brassard Weight (p<.00000)	6.22 (0.65)	5.94 (0.83)	6.37 (0.90)	6.33 (0.69)	6.39 (0.61)	4.67 (1.41)
Overall Weight (p<.00000)	5.78 (1.11)	5.53 (0.94)	6.21 (0.85)	6.28 (0.67)	5.83 (0.92)	*3.67 (1.64)*
Flexibility/ Stiffness (p<.00000)	5.94 (0.54)	4.83 (1.08)	6.00 (0.94)	5.50 (0.79)	5.28 (1.02)	*3.11 (1.18)*
Thickness (p<.00000)	5.72 (1.02)	5.06 (0.90)	6.21 (0.79)	5.89 (0.96)	5.22 (1.17)	*3.61 (1.61)*
Bulk (p<.00000)	5.61 (1.14)	5.23 (0.90)	6.00 (1.05)	5.94 (1.16)	5.06 (1.30)	*3.44 (1.10)*
Trunk Forward Flexion (p<.00000)	5.89 (0.90)	5.23 (1.03)	6.11 (0.81)	6.28 (0.75)	5.56 (0.86)	*3.89 (1.02)*
Trunk Lateral Flexion (p<.00000)	5.83 (0.86)	5.18 (1.01)	6.11 (0.88)	6.22 (0.73)	5.56 (0.86)	*3.83 (1.25)*
Trunk Rotation (p<.00000)	5.94 (0.80)	5.24 (1.09)	6.05 (0.85)	6.33 (0.69)	5.56 (0.92)	*3.83 (1.38)*
Shoulder Adduction (p<.00000)	5.94 (0.80)	5.29 (1.05)	5.84 (1.17)	6.11 (0.68)	5.50 (0.86)	*3.78 (1.35)*
Shoulder Flexion (p<.00000)	6.00 (0.84)	5.24 (1.09)	5.89 (1.05)	6.22 (0.73)	5.39 (0.85)	4.19 (1.27)
Hip Flexion (p<.00000)	5.83 (0.79)	5.18 (0.95)	6.05 (0.85)	6.44 (0.70)	5.67 (0.84)	*3.89 (1.41)*
Overall ROM (p<.00000)	5.89 (0.83)	5.29 (1.05)	6.11 (0.81)	6.28 (0.67)	5.67 (1.03)	*3.56 (1.20)*
Breathing Constriction (p<.00001)	5.94 (1.21)	5.59 (0.87)	6.11 (0.99)	5.89 (1.18)	5.67 (1.46)	4.44 (1.50)
Pressure Points (p<.00015)	6.11 (1.23)	5.65 (1.00)	6.26 (0.65)	6.28 (0.75)	5.94 (1.16)	4.67 (1.71)
Chaffing (p<.00068)	6.56 (0.86)	6.18 (0.88)	6.11 (0.88)	6.22 (1.00)	6.39 (1.09)	5.00 (1.78)
Physical Comfort (p<.00000)	6.28 (0.75)	5.59 (0.94)	6.16 (0.60)	6.00 (1.08)	6.06 (0.64)	4.50 (1.34)
Hot Spots (p<.00026)	5.50 (1.15)	5.47 (0.62)	5.68 (1.06)	5.80 (1.05)	5.39 (1.09)	4.28 (1.32)
Ventilation (p<.00001)	5.06 (1.06)	4.76 (1.52)	5.25 (1.29)	5.33 (1.19)	4.78 (1.17)	*3.72 (1.32)*
Thermal Comfort (p<.00000)	5.28 (1.13)	4.82 (1.29)	5.16 (1.57)	5.72 (0.89)	5.06 (1.30)	3.94 (0.94)
C7 (p<.00000)	5.72 (0.67)	5.29 (0.77)	5.89 (1.52)	5.83 (1.04)	5.89 (0.96)	*3.17 (1.47)*
C9 (p<.00000)	6.00 (0.84)	5.94 (1.03)	6.37 (0.83)	6.61 (0.61)	6.44 (0.62)	4.44 (1.98)
C6 (p<.00000)	6.17 (0.99)	6.06 (1.09)	6.53 (0.61)	6.60 (0.61)	6.33 (1.03)	4.45 (2.01)
M72 (p<.00020)	6.17 (0.92)	5.88 (1.05)	6.05 (1.27)	6.67 (0.69)	6.33 (0.84)	5.33 (1.41)
Carl Gustav (p<.07491)	6.44 (0.62)	6.29 (0.99)	6.26 (1.19)	6.39 (0.98)	6.67 (0.59)	6.04 (1.04)
Driving Vehicle (p<.00000)	6.44 (0.71)	5.47 (1.18)	6.26 (1.19)	6.67 (0.69)	6.39 (0.85)	4.61 (1.94)
Turret Gunner (p<.00001)	6.39 (0.78)	5.94 (1.30)	6.47 (0.70)	6.78 (0.65)	6.51 (0.85)	5.30 (1.65)
Clothing Compatibility (p<.01626)	6.44 (0.70)	6.15 (0.60)	6.43 (0.67)	6.44 (0.90)	6.49 (0.59)	5.78 (1.25)
Standing (p<.00574)	5.78 (1.22)	6.00 (1.12)	6.47 (0.61)	6.17 (1.10)	5.88 (1.02)	5.11 (1.84)
Kneeling (p<.00144)	5.67 (0.97)	5.29 (1.65)	5.79 (1.69)	5.94 (1.21)	5.86 (1.08)	4.39 (2.00)
Prone (p<.00002)	6.33 (0.77)	6.00 (0.79)	6.42 (1.02)	6.33 (0.84)	6.39 (0.78)	4.56 (1.82)
Climbing (p<.00000)	6.17 (0.71)	5.71 (1.10)	6.26 (0.87)	6.33 (0.97)	6.15 (0.79)	4.27 (1.44)
Crawling (p<.00000)	6.22 (0.65)	5.65 (1.11)	6.16 (1.30)	6.50 (0.99)	5.93 (1.21)	4.32 (1.36)
Throwing (p<.00000)	6.00 (0.77)	5.29 (1.16)	6.16 (1.01)	6.17 (1.15)	5.81 (0.86)	4.09 (1.38)
Twisting (p<.00000)	6.11 (0.58)	5.59 (0.94)	6.21 (0.92)	6.22 (1.11)	5.87 (0.68)	4.04 (1.45)
Overall Rating (p<.00000)	6.00 (0.77)	5.59 (1.00)	6.11 (0.66)	6.28 (0.67)	5.89 (0.76)	3.94 (1.47)

- Perceived Exertion: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Ease of Assembly: Condition $N_{initial}$ was significantly worse than condition E, G, and the FPV. The FPV was significantly better than conditions B, C, and E.
- Stability: Condition $N_{initial}$ was significantly worse than condition E and the FPV.

- Brassard Weight: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Overall Weight: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Flexibility/ Stiffness: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition B and E.
- Thickness: Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV. Condition C was significantly worse than condition E.
- Bulk: Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV.
- ROM (Trunk Forward Flexion): Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- ROM (Trunk Lateral Flexion): Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- ROM (Trunk Rotation): Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- ROM (Shoulder Adduction): Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- ROM (Shoulder Flexion): Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV. Condition C was significantly worse than conditions B and the FPV.
- ROM (Hip Flexion): Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- Overall ROM: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- Breathing Constriction: Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV.
- Pressure Points: Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV.
- Chaffing: Condition $N_{initial}$ was significantly worse than conditions B and G.
- Overall Physical Comfort: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G. Condition C was significantly worse than condition B.
- Hot Spots: Condition $N_{initial}$ was significantly worse than condition E and the FPV.
- Ventilation: Condition $N_{initial}$ was significantly worse than conditions B, E, and the FPV.
- Overall Thermal Comfort: Condition $N_{initial}$ was significantly worse than conditions B, E, G, and the FPV.
- C7: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly worse than condition E.
- C9: Condition $N_{initial}$ was significantly worse than conditions E, G, and the FPV.

- C6: Condition $N_{initial}$ was significantly worse than conditions E, G, and the FPV.
- M72: The FPV was significantly better than conditions C and $N_{initial}$.
- Driving Vehicle: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Turret Gunner: Condition $N_{initial}$ was significantly worse than conditions B, E, G, and the FPV.
- Standing: Condition $N_{initial}$ was significantly worse than condition E.
- Kneeling: Condition $N_{initial}$ was significantly worse than condition B, E, G and the FPV.
- Prone: Condition $N_{initial}$ was significantly worse than conditions B,C, E, G, and the FPV.
- Climbing: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Crawling: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Throwing: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- Twisting: Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.
- **Overall Rating:** Condition $N_{initial}$ was significantly worse than conditions B, E, FPV, and G.

4.1.7 Thermal Comfort

Participants completed a thermal discomfort questionnaire indicating level and location of discomfort following each test condition – see Table 12. The following table shows the locations of discomfort with the number of participants indicating ratings greater than or equal to 2 and these participants' average discomfort ratings in parentheses. The most common discomfort areas were the front and back torso areas. The next most common area was the lower back but it only received 4 ratings compared to the 77 that the front and back torso received.

Neutral	Slightly Warm	Noticeably Warm	Hot	Very Hot
1	2	3	4	5

Figure 6: Thermal Discomfort Scale

Table 12: Thermal Discomfort by Location

Location	B	C	E	FPV	G	$N_{initial}$
Front/Back Torso	12 (3)	13 (2.7)	15 (2.8)	13 (2.8)	12 (3.1)	12 (3.25)
Neck					1 (4)	
Chest					1 (5)	
Front Torso		1 (2)		1 (2)	1 (2)	
Hips						
Lower Back	1 (3)	1 (4)		1 (3)		1 (3)
Throat	1 (2)				1 (2)	
Arms			1 (3)			
Sides				1(3)		
Shoulders		1 (2)			1 (2)	
TOTAL	14	16	16	16	17	13

4.1.8 Physical Comfort

Participants completed a physical discomfort questionnaire regarding the level and location of discomfort – see Table 13. The following table shows the location of discomfort with the number of participants indicating ratings greater than or equal to 2 and these participants' average discomfort rating in parentheses. The most common area of physical discomfort was the shoulders followed by the front and back torso. Condition C had the most areas affected by physical discomfort followed by B, G, and the FPV.

Neutral	Slight Discomfort	Noticeable Discomfort	Pain	Extreme Pain
1	2	3	4	5

Figure 7: Physical Discomfort Scale

Table 13: Physical Discomfort by Location

Location	B	C	E	G	$N_{initial}$	FPV
Arms	1 (2)	1 (2)	2 (2)	1 (3)		
Back	1 (2)		1(2)			4 (3)
Shoulders	3 (2)	3 (2)	3 (2)	2 (3)	2 (3)	
Sides	1 (2)					2 (2.5)
Chest	1 (3)					1 (2)
Front/Back Torso		3 (2.67)		3 (2)	3 (2.67)	1 (3)
Front Torso		1 (2)				
Hips		1 (2)	2 (2)	1 (2)		
Back		1 (3)				
Neck					3 (2.67)	2 (3)
Low Back				1 (3)	1 (3)	
TOTAL	7	10	8	8	9	10

Participants were also asked to complete a CALM questionnaire, in which participants indicated between two descriptors which one better described the soft armour material. Lower scores reflect

the first descriptive (in the first column i.e. warm), while higher scores reflect the second term (in first column i.e. cool). Friedman non-parametric ANOVA was performed on the data and an appropriate post hoc analysis was conducted. All instances where there were significant differences are shaded and a more detailed analysis is given below Table 14. Condition $N_{initial}$ was found to be warmer, damper, harder, stiffer, rougher, thicker, heavier, denser, and non- stretchy when compared to all the other conditions. Conditions B and E seemed to have more favourable results when compared to conditions G and C. However, these differences are small and not systematic throughout all of the material ratings.

Participants also provided a single CALM score to reflect the overall comfort of the system on a scale from *'Greatest Imaginable Discomfort'* (-100) to *'Greatest Imaginable Comfort'* (100). Conditions B, FPV, E, and G had scores that were between 'moderately comfortable' to 'very comfortable', while condition $N_{initial}$ had a rating approaching 'slightly uncomfortable'. Condition C had a rating between 'slightly comfortable' to 'moderately comfortable'.

Table 14: CALM Ratings by Condition

Factor (n=17)	B	C	E	FPV	G	$N_{initial}$
Warm/Cool (p<.00024)	3.35 (1.27)	3.06 (1.48)	3.00 (1.12)	3.10 (1.18)	2.89 (0.76)	2.05 (0.85)
Damp/Dry (p<.54522)	3.82 (1.63)	3.64 (1.62)	3.50 (1.35)	3.53 (1.46)	3.50 (0.99)	3.00 (1.05)
Hard/Soft (p<.00000)	4.00 (1.17)	2.94 (1.14)	4.60 (1.10)	3.47 (1.29)	3.89 (0.96)	2.42 (1.07)
Stiff/Flexible (p<.00000)	4.18 (1.07)	3.18 (1.33)	4.50 (1.19)	3.53 (1.33)	3.83 (1.10)	2.05 (0.97)
Rough/Smooth (p<.00172)	4.24 (1.15)	3.76 (0.97)	4.18 (1.35)	4.00 (1.19)	4.33 (0.77)	3.05 (1.31)
Clean/Fuzzy (p<.49098)	3.59 (1.23)	3.71 (0.92)	3.75 (1.25)	3.48 (1.04)	3.72 (1.13)	3.95 (1.39)
Thick/Thin (p<.00008)	3.65 (1.22)	3.41 (1.06)	3.80 (1.20)	3.36 (0.84)	3.83 (0.99)	2.42 (1.12)
Heavy/Light (p<.00000)	3.82 (0.81)	3.47 (1.18)	3.95 (1.15)	4.09 (1.24)	4.00 (1.28)	2.05 (1.22)
Loose/Dense (p<.00163)	4.59 (1.12)	4.53 (0.80)	4.30 (0.86)	4.98 (0.84)	4.72 (0.75)	5.00 (1.20)
Non Stretchy/Very Stretchy (p<.00713)	4.18 (0.88)	3.35 (1.11)	3.80 (1.20)	3.99 (1.42)	4.11 (1.28)	3.26 (1.37)
Noisy/Quiet (p<.67123)	5.18 (1.38)	5.35 (1.37)	5.05 (1.28)	5.11 (1.32)	5.06 (1.43)	4.58 (1.26)
CALM (p<.00000)	47.41 (7.26)	22.05 (7.26)	48.75 (6.70)	45.72 (7.06)	41.94 (7.06)	9.77 (7.06)

- Warm/Cool: Condition $N_{initial}$ was found to be significantly warmer than Condition B.
- Hard/Soft: Condition $N_{initial}$ was significantly harder than conditions B, E, and G. Condition C was also found to be significantly harder than condition E.
- Stiff/Flexible: Condition $N_{initial}$ was significantly stiffer than conditions B, E, and G. Condition C was also found to be significantly stiffer than condition E.
- Rough/Smooth: Condition $N_{initial}$ was significantly rougher than G.
- Thick/Thin: Condition $N_{initial}$ was found to be thicker than conditions B, E, and G.
- Heavy/Light: Condition $N_{initial}$ was found to be heavier than conditions B, E, FPV, and G.
- CALM: Condition $N_{initial}$ was found to be significantly more uncomfortable than conditions B, E, FPV, and G.

4.1.9 Final Exit Questionnaire

At the conclusion of the trial, participants completed a final exit questionnaire where they rated the conditions against each other based on the 7-point acceptability scale. Instances where significant differences were found based on a Friedman non-parametric ANOVA are shaded in Table 15. Conditions B, FPV, and E had scores that were between 'barely acceptable' and 'completely acceptable', while conditions G had scores between 'barely acceptable' and 'reasonably acceptable', and condition C had scores ranging from 'borderline' and 'reasonably acceptable'. Condition $N_{initial}$ had scores between 'reasonably unacceptable' and 'barely unacceptable' for all instances. All significant differences are detailed below Table 15.

Table 15: Final Exit Ratings

Factor (n=18)	B	C	E	FPV	G	$N_{initial}$
ROM (p<.00000)	5.76 (0.75)	4.76 (1.39)	5.88 (0.99)	6.24 (0.97)	5.29 (0.85)	2.53 (1.42)
Mobility (p<.00000)	5.88 (0.78)	5.00 (1.58)	6.00 (1.00)	6.53 (0.72)	5.47 (1.12)	2.53 (1.42)
Bulk (p<.00000)	5.88 (0.99)	5.41 (1.18)	6.24 (0.90)	6.29 (0.85)	5.18 (1.19)	2.59 (1.58)
Weight (p<.00000)	6.18 (0.81)	5.41 (1.77)	6.11 (0.99)	6.35 (0.86)	5.53 (1.12)	2.18 (1.29)
Flexibility (p<.00000)	5.53 (0.87)	4.53 (1.66)	5.88 (0.93)	5.71 (0.99)	5.17 (1.07)	2.47 (1.42)
Comfort (p<.00000)	6.06 (0.66)	5.35 (1.41)	6.35 (0.70)	5.82 (1.07)	5.65 (1.06)	2.82 (1.78)
Compatibility (p<.00000)	5.82 (0.73)	4.94 (1.56)	6.12 (0.93)	6.00 (0.71)	5.35 (0.93)	2.71(1.49)
Overall (p<.00000)	5.88 (0.70)	4.94 (1.43)	6.18 (0.88)	6.00 (0.71)	5.35 (0.86)	2.41 (1.46)

- ROM: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- Mobility: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- Bulk: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition G was significantly worse than condition E and the FPV.
- Weight: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C is significantly worse than the FPV.
- Flexibility: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- Comfort: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly was than condition E.
- Compatibility: Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly worse than condition E and the FPV.
- **Overall:** Condition $N_{initial}$ was significantly worse than conditions B, C, E, FPV, and G. Condition C was significantly worse than B, E, and the FPV.

4.1.10 Focus Group

Following completion of all conditions by all participants, participants took part in a HF expert guided focus group. Participants discussed any concerns with any of the conditions and relevant comments were noted. Participants were also asked to discuss each of the conditions based on the criteria of the exit questionnaire. The focus group allowed discussion of each of the conditions

based upon ROM, stability, mobility, bulk, weight, flexibility, comfort, compatibility, and overall impression. Table 16 provides the comments that participants gave during the focus group, as well as, the percentage of participants that agreed with the selected comment (where applicable).

Table 16: Focus Group Comments

Comment	Agreement (%)
Range of Motion	
Condition $N_{initial}$ was the worst	71
Condition G was the worst	14
Condition C was the worst	14
Most participants preferred conditions B , E, and the FPV	
Stability	
Condition $N_{initial}$ had the worst stability	29
Stability issues can be resolved by not switching vests	-
Mobility	
The FPV was the best for mobility	43
Bulk	
Condition $N_{initial}$ was the bulkiest	57
Condition C was the bulkiest	14
Condition G was the bulkiest	14
Weight	
Condition $N_{initial}$ was the heaviest	100
No difference in weight between conditions E, B, C	-
The FPV was the lightest	29
Flexibility	
Conditions E and B are flexible	-
Condition C was too stiff	57
Comfort	
All of the fill packs were the same for comfort	57
FPV was the most comfortable	29
Condition C produced pressure points while in vehicle	-
Compatibility	
Issues with the C7 in the prone position with condition $N_{initial}$	86
MTBAS Collar clashed with helmet in the prone position	57
Overall	
Condition B was the best	14
Condition E was the best	57
Condition G was the best	29

4.2 Phase 1a Results

4.2.1 Anthropometric Measurements

The main anthropometric measures that were taken were stature and chest circumference. The average stature of the participants was 180.99 cm with a minimum of 176.4 cm that coincides with the 55th percentile male, according to the Canadian Forces Land Forces Anthropometric Survey in 1997 (Chamberland et al., 1997), and a maximum stature of 186.6 cm, which coincides with greater than the 97th percentile male. The average chest circumference was 100.35 cm with a

minimum of 89 cm, which coincides with the 5th percentile male, and a maximum chest circumference of 107.5 cm, which coincides with the 75th percentile male – see Table 17. Based on these measurements eight of the eleven participants fit into a medium-regular sized vest, while one participant fit into each of the large-tall, medium-short, and large-regular vests.

Table 17: Anthropometric Measurements of Participants

(N=11)	Mean (SD)	Min (percentile male)	Max (percentile male)
Stature (cm)	180.99 (3.72)	176.40 (55%)	186.60 (97%)
Chest Circumference (cm)	100.35 (5.89)	89.00 (5%)	107.50 (75%)

4.2.2 Range of Motion

All participants were measured for a series of joint ranges of motion while wearing the soft armour conditions with the MTBAS carrier. The results are shown below in Table 18. A repeated measures ANOVA was used to identify any significant differences between the conditions. Significant differences were observed for trunk forward flexion and trunk lateral flexion. Condition A performed the worst in most measures. Averages are shown below with the standard deviations in parentheses. Condition descriptions are shown in Table 3.

Table 18: Ranges of Motion by Condition

Factor (n=11)	A	B	D	G	N_{final}
Trunk- Forward Flexion (cm) p-value<0.00002	22.92 (7.59)	26.65 (8.17)	25.30 (7.42)	26.56 (8.03)	28.05 (7.85)
Trunk- Lateral Flexion(°) p-value<0.02451	38.23 (5.69)	40.86 (7.81)	40.95 (7.17)	39.50 (7.30)	35.77 (5.70)
Shoulder Adduction(°) p-value<0.30819	108.00 (6.53)	111.00 (4.80)	110.73 (7.61)	111.23 (4.68)	109.77 (4.89)
Trunk – Rotation(°) p-value<0.39707	35.41 (9.76)	38.14 (10.63)	39.73 (11.03)	40.05 (10.80)	41.27 (12.05)
Hip Flexion(°) p-value<0.32444	70.18 (5.15)	67.45 (5.42)	68.32 (4.68)	67.64 (5.06)	67.95 (4.10)

Note: Hip flexion angles were measured between the trunk and the thigh while the subject lay supine. Therefore, smaller measured angles refer to greater levels of hip flexion.

- Trunk Forward Flexion – Condition A was significantly worse than conditions B, G, and N_{final}.
- Trunk Lateral Flexion – Condition N_{final} was significantly worse than conditions B and D.

4.2.3 Weapons Compatibility

All participants evaluated the compatibility of a selection of weapons with each soft armour condition. Each participant was guided through normal weapons handling drills and gave the HF observer a subjective rating based on the 7-point acceptability scale. Average ratings are shown below in Table 19 with standard deviations in parentheses. For conditions B, G, and N_{final} most of the ratings were between 'reasonably acceptable' and 'completely acceptable'. Condition D ratings were between 'barely acceptable' and 'completely acceptable. The lowest ratings were found with condition A where the majority of the scores were between 'borderline' and 'reasonably acceptable'. Furthermore, firing in the prone position with the C7A1 in condition A was found to

be unacceptable. Friedman non-parametric ANOVA was performed on the data with a post hoc analysis describing differences between conditions. The critical absolute error value was found to be 1.89250 with all differences greater than this value considered significant. The results of the analysis are described below with significant differences shaded. Areas that were found to be unacceptable are italicized.

Table 19: Weapons Compatibility by Condition

Factor (n=11)	A	B	D	G	N_{final}
C7A1 Standing (p-value< 0.00003)	4.09 (1.04)	6.27(1.19)	5.73 (1.01)	6.45 (0.69)	6.36 (0.67)
C7A1 Kneeling (p-value <0.00098)	4.00 (1.41)	5.91 (0.54)	5.55 (1.21)	6.18 (0.98)	6.18 (0.60)
C7A1 Prone (p-value <0.00010)	*3.73 (1.79)*	6.18 (0.87)	5.91 (1.38)	6.55 (0.69)	6.45 (0.69)
C6 (p-value <0.01836)	4.55 (1.29)	5.82 (0.75)	5.55 (1.37)	6.18 (0.87)	5.91 (0.83)
C9 (p-value <0.00053)	4.64 (1.29)	6.00 (0.77)	6.00 (1.00)	6.36 (0.81)	6.18 (0.60)
Pistol (p-value <0.00270)	5.64 (0.92)	6.73 (0.47)	6.64 (0.67)	6.82 (0.40)	6.64 (0.67)
M72 (p-value <0.03759)	5.64 (1.21)	6.45 (0.93)	6.55 (0.69)	6.73 (0.47)	6.55 (0.69)
Carl Gustav (p-value <0.19392)	5.73 (0.90)	6.09 (0.70)	5.91 (1.30)	6.45 (0.52)	5.82 (0.98)

- C7A1 Standing: Conditions B, G, and N_{final} were found to be significantly better than condition A.
- C7 Kneeling: Conditions G and N_{final} were found to be significantly better than condition A.
- C7 Prone: Conditions B, G, and N_{final} were found to be significantly better than condition A.
- C6: Condition G was found to be significantly better than condition A.
- C9: Conditions G and N_{final} were found to be significantly better than condition A.

4.2.4 Discrete Mobility Tasks

All participants completed a series of discrete mobility tasks wearing each of the soft armour conditions. Descriptions of the results of each task are described below – see Table 20. A repeated measures ANOVA was conducted for each task to identify significant differences.

Vertical Leap

The average vertical leap measurements ranged from 268.09 cm with condition D to 270.09 cm with condition N_{final} – see Table 20. All measurements are shown in Table 20 with standard deviations in parentheses. There was only a 2 cm difference in performance between the best performing condition and the worse and the repeated measures ANOVA did not find any significant differences between conditions.

Stepping Sprint

The number of step cycles in 30 seconds ranged from 37.00 cycles with condition A to 39.09 cycles with condition B – see Table 20. This is a difference of approximately 2 cycles. With standard deviation ranging from 3 – 5 cycles there were no significant differences between conditions during the stepping sprint.

Wall Touch

The number of touches in 30 seconds ranged from 45.09 touches with condition A to 48.73 touches with condition N_{final} – see Table 20. The gap between the best performing condition and the worst performing condition was approximately 3 touches, which translates to less than 1 complete cycle of the wall touch apparatus. Significant differences were found in the wall touch where Conditions B and N_{final} outperformed condition A.

Agility Run

The time needed to complete the agility course ranged from 11.24 seconds with condition N_{final} to 11.74 seconds with condition A – see Table 20. The difference between the worst performing condition and the best performing condition was half a second. There were no significant differences in time between the conditions.

20 m Sprint

The time needed to complete the 20 m sprint ranged from 4.03 seconds with condition D to 4.06 seconds for conditions N_{final} and G – see Table 20. Therefore, the difference between the best and worst performing conditions is approximately three one hundredths of a second. There were no significant differences between the conditions in the participant's time to sprint 20 m.

Grenade Toss

As part of the discrete mobility tasks, participants were instructed to toss a tennis ball in the prone position as if it were a grenade. Participants then provided a subjective rating to the HF observer based on the 7-point acceptability scale. Conditions A and D had scores ranging from 'barely acceptable' to 'reasonably acceptable', while conditions B, G, and N_{final} had scores between 'reasonably acceptable' to 'completely acceptable'. A Friedman non-parametric ANOVA was performed to identify differences. A post hoc Friedman test was used, to test multiple comparisons, to compare the average rank of all the conditions to an absolute critical value and identify differences among the conditions. The absolute critical value was found to be 1.8925 and the only difference was found to be between condition A and conditions G and N_{final} (1.9545) where they were found to be more acceptable than condition A.

Table 20: Discrete Mobility Scores by Condition

Factor (n=11)	A	B	D	G	N_{final}
Vertical Leap (cm) p-value<0.30976	69.91 (13.22)	69.09 (9.74)	68.09 (10.53)	70.00 (10.55)	70.09 (9.61)
Agility Run (seconds) p-value<0.57343	11.74 (1.05)	11.41 (1.28)	11.53 (1.05)	11.70 (1.10)	11.24 (0.94)
Stepping Sprint (cycles) p-value<0.17273	37.00 (3.49)	39.09 (3.24)	37.55 (3.83)	37.09 (4.78)	39.00 (3.79)
20 m Sprint (seconds) p-value<0.99841	4.05 (0.34)	4.06 (0.34)	4.03 (0.36)	4.06 (0.18)	4.04 (0.26)
Wall Touches (touches) p-value<0.00403	45.09 (4.12)	48.14 (5.32)	46.09 (5.03)	47.73 (4.31)	48.73 (4.93)
Grenade Toss p-value <0.00319	5.00 (1.41)	6.09 (0.70)	5.82 (0.75)	6.27 (0.65)	6.36 (0.67)

- Wall Touch – Condition A was significantly worse than conditions B and $N_{final.}$

- Grenade Toss- Condition A was significantly worse than conditions G and $N_{final.}$

4.2.5 Condition Exit Questionnaire

At the conclusion of each iteration, participants completed a condition exit questionnaire which evaluated a wide range of criteria. The ratings of each condition are shown in Table 21. Borg RPE results show that condition A had the highest level of perceived exertion followed by D, B, and G, with N_{final} having the lowest level of perceived exertion.

The remaining subjective scores were based on the standard 7-point scale of acceptability. For condition A the majority of the scores were between ‘borderline’ and ‘reasonably acceptable’ with flexibility, stiffness, thickness, bulk, C7 acceptability, and adopting the prone position receiving unacceptable scores. The majority of scores for condition D were between ‘borderline’ and ‘reasonably acceptable’ with no areas receiving unacceptable scores. The majority of scores for conditions B, G, and N_{final} were between ‘barely acceptable’ and ‘completely acceptable’ with no areas receiving unacceptable ratings. Friedman’s ANOVA was performed on the data to identify significant differences, as well as, a post hoc analysis designed for the Friedman ANOVA. The results of the analysis are described below. All areas that were found to have a significant difference are shaded with unacceptable values italicized.

Table 21: Condition Exit Results

Factor (n=11)	A	B	D	G	N_{final}
Perceived Exertion (p<.00003)	14.09 (2.63)	11.91 (3.39)	12.55 (2.58)	11.27 (2.61)	10.64 (2.73)
Fit (p<.00920)	5.09 (1.14)	6.36 (0.67)	5.64 (1.12)	6.20 (0.63)	5.91 (1.14)
Ease of Assembly (p<.01939)	4.27 (1.68)	5.64 (1.50)	5.64 (1.80)	5.64 (0.92)	5.45 (1.13)
Stability (p<.02642)	5.27 (0.65)	6.09 (0.83)	5.82 (0.98)	5.91 (0.83)	6.09 (0.70)
Brassard Weight (p<.00183)	5.18 (1.40)	6.40 (0.70)	5.64 (0.67)	6.27 (0.47)	6.36 (0.67)
Overall Weight (p<.00102)	4.55 (1.51)	6.00 (1.18)	5.60 (1.43)	6.45 (0.52)	6.18 (0.60)
Flexibility/Stiffness (p<.00001)	*3.91 (1.04)*	5.55 (1.37)	5.00 (1.18)	6.18 (0.60)	6.09 (0.70)
Thickness (p<.00001)	*3.73 (1.27)*	5.82 (1.25)	5.73 (0.90)	6.27 (0.90)	6.36 (0.67)
Bulk (p<.00001)	*3.64 (1.21)*	5.64 (1.50)	5.36 (0.67)	6.27 (0.65)	5.82 (0.87)
Trunk Forward Flexion (p<.00250)	4.27 (1.10)	5.82 (0.87)	5.45 (1.13)	5.91 (0.70)	5.91 (0.83)
Trunk Lateral Flexion (p<.00191)	4.36 (1.36)	5.73 (1.10)	5.55 (0.52)	6.09 (0.70)	6.00 (0.89)
Trunk Rotation (p<.00426)	4.45 (1.13)	5.82 (0.98)	5.55 (0.69)	5.91 (0.94)	5.91 (0.83)
Shoulder Adduction (p<.01342)	4.27 (1.56)	5.91 (0.94)	5.27 (0.90)	5.64 (1.12)	5.91 (0.83)
Shoulder Flexion (p<.00026)	4.27 (1.19)	5.91 (0.83)	5.36 (1.12)	5.82 (0.87)	6.09 (0.83)
Hip Flexion (p<.04019)	4.70 (1.42)	5.82 (0.87)	5.55 (0.93)	5.82 (0.75)	6.09 (0.83)
Overall ROM (p<.00203)	4.27 (1.27)	6.09 (0.83)	5.50 (0.85)	5.91 (0.70)	6.09 (0.83)
Pressure Points (p<.01547)	5.36 (1.21)	6.64 (0.50)	5.82 (0.98)	6.27 (0.79)	6.00 (1.00)
Breathing Constriction (p<.02191)	5.18 (1.25)	6.09 (0.83)	6.18 (0.60)	6.27 (0.47)	6.09 (0.83)
Chaffing (p<.23518)	5.55 (1.29)	6.36 (0.67)	6.27 (0.65)	6.36 (0.67)	6.18 (0.75)
Physical Comfort (p<.00052)	4.73 (1.49)	6.27 (0.79)	5.73 (0.90)	6.27 (0.47)	6.00 (1.10)
Hot Spots (p<.09712)	4.50 (1.58)	5.55 (1.29)	4.91 (1.14)	5.10 (1.29)	5.36 (1.21)
Ventilation (p<.07240)	4.00 (1.34)	5.00 (1.26)	4.36 (1.50)	4.73 (1.27)	4.82 (0.98)
Thermal Comfort (p<.05747)	4.00 (1.61)	5.18 (1.47)	4.73 (1.42)	5.09 (1.04)	5.00 (1.00)
C7 (p<.00002)	*3.64 (1.12)*	6.18 (0.98)	5.45 (0.93)	6.36 (0.67)	6.36 (0.67)
C9 (p<.00020)	4.45 (1.29)	6.09 (0.83)	6.00 (0.89)	6.18 (0.75)	6.27 (0.65)
C6 (p<.00860)	4.36 (1.12)	5.91 (0.94)	5.82 (0.98)	6.00 (0.89)	6.36 (0.50)
M72 (p<.00421)	5.64 (1.21)	6.55 (0.69)	6.55 (0.69)	6.45 (0.69)	6.36 (1.21)
Carl G (p<.14783)	5.36 (1.69)	6.10 (0.99)	5.73 (1.74)	6.27 (0.65)	5.91 (1.30)
Standing (p<.00001)	4.00 (1.18)	6.27 (0.90)	5.73 (1.27)	6.27 (0.65)	6.55 (0.52)
Kneeling (p<.00007)	4.18 (1.54)	6.27 (0.65)	5.09 (1.22)	6.36 (0.67)	6.36 (0.50)
Prone (p<.00059)	*3.91 (1.58)*	5.64 (1.12)	5.73 (1.27)	6.27 (0.90)	6.18 (0.75)
Climbing (p<.00399)	4.55 (1.57)	6.27 (0.47)	6.00 (0.63)	6.18 (0.75)	6.18 (0.87)
Crawling (p<.00024)	4.18 (1.60)	6.27 (0.65)	6.00 (0.89)	6.27 (0.65)	6.27 (0.65)
Throwing (p<.00005)	4.36 (1.29)	6.00 (1.10)	5.45 (0.89)	6.27 (0.79)	6.18 (0.60)
Twisting (p<.00211)	4.36 (1.50)	5.91 (0.83)	5.55 (0.82)	6.00 (0.63)	6.18 (0.87)
Overall Rating (p<.00026)	4.27 (1.74)	6.00 (1.18)	5.55 (0.69)	6.18 (0.40)	6.09 (1.14)

- Perceived Exertion: Conditions G and N_{final} were significantly better than condition A.
- Fit: Condition B was significantly better than condition A.
- Overall Weight: Condition G was significantly better than condition A.
- Flexibility/ Stiffness: Conditions G and N_{final} were significantly better than condition A.
- Thickness: Conditions B, G, and N_{final} were significantly better than condition A.
- Bulk: Conditions B, G, and N_{final} were significantly better than condition A.
- Trunk Forward Flexion: Conditions B, D, G, and N_{final} were significantly better than condition A.

- Trunk Lateral Flexion: Conditions B, D, G, and N_{final} were significantly better than condition A.
- Trunk Rotation: Conditions B, D, G, and N_{final} were significantly better than condition A.
- Shoulder Adduction: Conditions B, G, and N_{final} were significantly better than condition A.
- Shoulder Flexion: Conditions B, G, and N_{final} were significantly better than condition A.
- Overall Range of Motion: Conditions B, D, G, and N_{final} were significantly better than condition A.
- Overall Physical Comfort: Conditions B, G, and N_{final} were significantly better than condition A.
- C7: Conditions B, G, and N_{final} were significantly better than condition A.
- C9: Conditions B, G, and N_{final} were significantly better than condition A.
- C6: Condition N_{final} was significantly better than condition A.
- Standing Fire: Conditions B, G, and N_{final} were significantly better than condition A.
- Kneeling Fire: Conditions B, G, and N_{final} were significantly better than condition A.
- Prone Fire: Conditions G and N_{final} were significantly better than condition A.
- Crawling: Conditions B, D, G, and N_{final} were significantly better than condition A.
- Throwing: Conditions B, G, and N_{final} were significantly better than condition A.
- **Overall:** Conditions B, G, and N_{final} were significantly better than condition A.

4.2.6 Thermal Comfort

Participants completed a thermal discomfort questionnaire regarding the level and location of discomfort – see Table 22. The following table shows the location of discomfort with the number of participants who rated it greater than or equal to 2 and the average of these participants' discomfort ratings in parentheses. Condition A had the greatest number of thermal discomfort issues followed by conditions G, N_{final}, and D with condition B having the least number of condition issues.

Table 22: Thermal Discomfort by Location

Location	A	B	D	G	N_{final}
Front/Back Torso	7 (3.71)	5 (2.8)	5 (2.8)	6 (2.83)	8 (3.13)
Neck			1 (3)		
Chest					
Front Torso			5 (3)	5 (3)	
Hips	2 (4)				
Low Back	6 (3.67)	3 (3.67)	3 (3.33)	2 (3)	4 (3.5)
Throat	1 (3)				
Arms	5 (3.4)	2 (4)		2 (3)	3 (2.67)
Sides	4 (3.75)	3 (3.67)	2 (3.5)	2 (3)	2 (3.5)
TOTAL	25	13	16	17	17

4.2.7 Physical Comfort

Participants completed a physical discomfort questionnaire regarding the level and location of discomfort – see Table 23. The following table shows the location of discomfort with the number of participants who rated it greater than or equal to 2 and the average discomfort rating of these participants in parentheses. The most common area of physical discomfort was the arms followed by the neck. Condition A had the most areas affected by physical discomfort followed by B, D, G, and N_{final}.

Table 23: Physical Discomfort by Location

Location	A	B	D	G	N_{final}
Front/ Back Torso	1 (4)		3 (2.33)	1 (4)	
Neck	3 (3)	3 (2.33)	2 (2.5)	1 (3)	2 (2.5)
Chest	3 (2.75)				
Front Torso		1 (2)			
Hips	2 (4)	5 (2)			
Low Back	1 (4)	1 (2)	1 (2)	1 (4)	
Throat	3 (2.75)	2 (2)			3 (2.33)
Arms		2 (2)	6 (2.33)	3 (2)	2 (2.5)
Sides	3 (4)				
Total	16	14	12	6	7

Participants were also asked to complete a CALM questionnaire, in which participants indicated between two descriptors which one better described the soft armour material. Lower scores reflect the first descriptive (in the first column i.e. warm), while higher scores reflect the second term (in first column i.e. cool). Friedman non-parametric ANOVA was performed on the data and an appropriate post hoc analysis was conducted. All instances where there were significant differences are shaded and a more detailed analysis is given below Table 24. Condition A was found to be warmer, damper, harder, stiffer, rougher, thicker, heavier, denser, and non- stretchy when compared to all the other conditions. Conditions B, G, and N_{final} seemed to have more favourable results when compared to condition D. However, these differences are small and not systematic throughout all of the CALM ratings.

Participants also provided a single CALM score to reflect the overall comfort of the system on a scale from ‘Greatest Imaginable Discomfort’ (-100) to ‘Greatest Imaginable Comfort’ (100). Conditions B, D, G, and N_{final} had scores that were between ‘very comfortable’ to ‘extremely

comfortable', while condition A had a rating of above 'slightly uncomfortable'. Condition B was found to be the most comfortable condition.

Table 24: CALM Ratings by Condition

Factor (n=11)	A	B	D	G	N_{final}
Warm/Cool (p<.06110)	1.91 (0.70)	2.36 (0.81)	2.36 (1.03)	2.91 (1.14)	2.91 (1.30)
Damp/Dry (p<.19196)	2.73 (1.19)	3.09 (1.70)	3.09 (1.14)	3.55 (1.51)	3.64 (1.50)
Hard/Soft (p<.00507)	3.18 (1.66)	4.45 (1.13)	3.82 (1.47)	4.73 (1.27)	5.00 (1.00)
Stiff/Flexible (p<.00048)	2.82 (1.66)	4.73 (1.56)	4.18 (1.33)	5.09 (1.38)	5.18 (1.08)
Rough/Smooth (p<.00405)	3.45 (1.13)	4.36 (0.81)	4.27 (0.65)	4.82 (0.87)	4.91 (0.94)
Clean/Fuzzy (p<.44573)	3.27 (1.19)	3.18 (1.08)	3.27 (0.79)	2.90 (0.88)	3.09 (0.83)
Thick/Thin (p<.00000)	1.64 (0.81)	4.36 (1.57)	4.36 (1.03)	5.64 (1.03)	5.55 (0.93)
Heavy/Light (p<.00000)	2.91 (0.94)	4.82 (1.25)	4.36 (0.92)	5.45 (0.69)	5.82 (0.60)
Loose/Dense (p<.60727)	4.64 (1.29)	4.36 (0.81)	4.09 (0.94)	4.27 (1.10)	4.27 (1.19)
Non Stretchy/Very Stretchy (p<.08611)	3.73 (0.90)	4.36 (0.92)	4.27 (0.79)	4.55 (0.52)	4.27 (0.79)
Noisy/Quiet (p<.03289)	4.91 (1.04)	5.55 (0.93)	5.09 (1.04)	5.36 (1.12)	5.55 (1.04)
CALM (p<.00016)	15.73 (36.02)	62.55 (21.12)	47.27 (23.67)	58.73 (15.88)	56.36 (28.24)

- Hard/Soft: Condition A was significantly harder than condition N_{final}.
- Stiff/Flexible: Condition A was significantly stiffer than conditions G and N_{final}.
- Thick/Thin: Condition A was significantly thicker than conditions B, G, D, and N_{final}.
- Heavy/Light: Condition A was significantly heavier than conditions B, G, and N_{final}.
- CALM: Condition A was significantly less comfortable than conditions B, G, and N_{final}.

4.2.8 Final Exit Questionnaire

At the conclusion of the trial participants completed a final exit questionnaire where they rated the conditions against each other based on the 7-point acceptability scale. Instances where significant differences were found based on Friedman non-parametric ANOVA and a Friedman post hoc analysis are shaded in Table 25. Instances that were found to be unacceptable are italicized. Conditions B, G, and N_{final} had scores that were between 'barely acceptable' to 'completely acceptable', while conditions D had scores between 'barely acceptable' to 'reasonably acceptable', and condition A had scores mostly below 'borderline' except for 'comfort' which was barely acceptable. All significant differences are detailed below Table 25 with the appropriate p-values.

Table 25: Final Exit Questionnaire Results

Factor (n=11)	A	B	D	G	N_{final}
ROM (p<.00003)	*3.27 (1.10)*	5.82 (0.98)	5.18 (1.25)	6.18 (0.75)	6.09 (1.04)
Mobility (p<.00001)	*3.36 (1.29)*	6.09 (0.83)	5.45 (1.21)	6.18 (0.40)	6.27 (1.01)
Bulk (p<.00000)	*2.36 (0.92)*	5.64 (0.81)	5.45 (1.13)	6.27 (0.90)	6.27 (0.65)
Weight (p<.00000)	*3.36 (1.21)*	5.91 (1.30)	5.55 (1.21)	6.00 (1.00)	6.45 (0.69)
Flexibility (p<.00005)	*3.64 (1.29)*	5.82 (0.87)	5.36 (1.21)	6.18 (0.87)	6.00 (1.10)
Comfort (p<.00028)	4.09 (1.81)	6.09 (1.22)	5.64 (1.12)	6.18 (0.75)	6.18 (0.87)
Compatibility (p<.00001)	*2.91 (1.22)*	5.73 (1.27)	5.36 (0.92)	6.18 (0.60)	6.00 (1.18)
Overall (p<.00002)	*3.36 (1.21)*	5.73 (0.90)	5.36 (1.21)	6.27 (0.47)	6.09 (1.04)

- ROM: Conditions B, G, and N_{final} were significantly better than condition A.
- Mobility: Conditions B, G, and N_{final} were significantly better than condition A.
- Bulk: Conditions B, G, D, and N_{final} were significantly better than condition A.
- Weight: Conditions B, G, D, and N_{final} were significantly better than condition A.
- Flexibility: Conditions B, G, and N_{final} were significantly better than condition A.
- Comfort: Conditions B, G, and N_{final} were significantly better than condition A.
- Compatibility: Conditions B, G, and N_{final} were significantly better than condition A.
- **Overall:** Conditions B, G, and N_{final} were significantly better than condition A.

4.2.9 Focus Group

Following completion of all conditions by all participants, participants took part in a HF expert guided focus group. Participants discussed any concerns with any of the conditions and noted relevant comments. Participants were also asked to rank each of the conditions based on the criteria of the exit questionnaire. The result of the participants input is given in Table 26. For each criterion in Table 26, participants were asked if they could vote for only one condition considering only that criterion. The overall ranking shows a split between conditions B, G, and N_{final}. Participants also indicated conditions that had severe (indicated as --- in Table 26), moderate (indicated as -- in Table 26), and minor (indicated as - in Table 26) problems with each criteria. Table 27 provides the comments that participants gave during the focus group, as well as, the percentage of participants that agreed with the selected comment.

Table 26: Participant Ranking of Conditions

Criteria	A	B	D	G	N_{final}
ROM	---	1	-	5	4
Mobility	---		-	5	3
Bulk	---		--	5	5
Weight	---	-	-	5	5
Flexibility				4	5
Comfort	---	3	-	1	7
Compatibility	---	5	-	2	4
Overall	-	5	-	2	4

Table 27: Focus Group Comments

Comment	Agreement (%)
Condition A was unacceptable for ROM	91
ROM problems with condition D	45
Condition N_{final} was best for ROM	36
Condition G was best for ROM	45
Condition B was a little bulky	45
Condition N_{final} was the lightest	55
Condition N_{final} had the best flexibility	45
Condition A was uncomfortable	27
Condition D was uncomfortable	45
Weapons compatibility problem with condition B	45
Weapons compatibility problems with condition D	64

This page intentionally left blank.

5 Discussion

5.1 General Discussion

Human factors tests included assessment of fit, anthropometry, range of motion, protective coverage assessment, compatibility with vehicles (Phase 1 only) and weapons, discrete mobility tasks, assault course, grenade throwing, thermal load, and physical comfort. Data collection included questionnaires, focus groups, performance measures, and HF observer assessments.

The participants in both phases of this trial represented a large proportion of the CF male population. It was essential for this evaluation that a variety of body sizes was used so that any differences would not be attributable to a single size of participants; however, the trial also worked with limited quantities of MTBAS carriers and it was even more important to ensure that every participant achieved a satisfactory fit. In general the participants represented approximately 90% of the anthropometric range of the CF male population.

5.1.1 Phase 1

Phase 1 tested conditions B, C, E, FPV, G, and $N_{initial}$. In general, conditions B, C, E, FPV, and G were acceptable in participant's subjective ratings while condition $N_{initial}$ was found to be unacceptable. In terms of objective measures, there were no significant differences between any of the conditions. Despite there being no significant differences in any of the objective measures, a trend was identified. In most of the objective measures, condition $N_{initial}$ performed worse than the other conditions, while conditions B and E generally performed the best. It should be restated that these differences were not found to be significant. When these results are compared to the subjective ratings of weapons/vehicle compatibility and in the exit questionnaires, condition $N_{initial}$ again is found to be worse than the other conditions. Notably, condition $N_{initial}$ was found to be unacceptable for ROM, mobility, bulk, weight, flexibility, comfort, compatibility, and overall ratings. Condition $N_{initial}$ was also found to be unacceptable for firing the C7A1 in all conditions where many participants felt that they could not obtain an accurate sight picture due to the stiffness and bulkiness of the condition. No other condition was found to be unacceptable for any other factor.

Identifying differences between conditions B, C, E, FPV, and G is more difficult. No differences were found between these conditions in objective measures or in most subjective measures. The focus group sessions revealed that condition C, while still acceptable, is less preferred to the other conditions. Overall data suggests that condition G also showed non-significant trends towards being less acceptable than other conditions. This leaves conditions B, E, and FPV as the most preferred conditions from Phase 1, even though condition G is still acceptable.

At the end of each use of the condition, participants completed a thermal and physical discomfort questionnaire. The most common area of thermal discomfort was the front and back torso where condition $N_{initial}$ had the highest mean rating compared to all other conditions. However, the difference between $N_{initial}$ and the other conditions was relatively small and it can be assumed that the thermal comfort of all conditions was relatively similar. There were no other areas of the body that were significantly affected by the thermal comfort of the conditions. In terms of physical discomfort the area of discomfort was more spread out to include the front and back torso, arms,

shoulders, hips, and neck. The FPV and condition C had the most accounts of physical discomfort, followed by condition $N_{initial}$, then conditions E and G, and finally by B. Participants also assessed the comfort of the systems by subjectively providing a score of comfort on a 200 point scale. All conditions received scores between slightly comfortable to moderately comfortable except for condition $N_{initial}$, which was the only condition to receive a slightly uncomfortable score. When participants were asked to evaluate the comfort of the conditions over a range of factors it was found that condition $N_{initial}$ was harder, stiffer, rougher, thicker, heavier, and denser than all other conditions.

5.1.2 Phase 1a

Phase 1a tested conditions A, B, D, G, and N_{final}. Substantial changes were made to condition N_{final} following Phase 1. Before introducing condition N_{final} to Phase 1a, the Spectra Shield material was cut down to cover approximately eighty percent of the torso area covered by the KM2 400 material. Furthermore, when condition N_{final} was introduced to Phase 1a, only the KM2 400 material was used in the accessory protection (neck, throat, groin, and brassards). In general, conditions B, D, and G were acceptable in participants' subjective ratings while condition A was found to be unacceptable. Importantly, condition A was found to be unacceptable for ROM, mobility, bulk, weight, flexibility, comfort, compatibility, and overall ratings. Condition A was also found to be unacceptable for firing the C7A1 in all conditions. Participants had trouble gaining a sight picture due to the increased bulk. In terms of objective measures, there was no significant difference between any of the conditions. The non-significant trend of worse objective performance with condition N_{final} in Phase 1 no longer appears to be present.

As in Phase 1, participants completed a thermal and physical discomfort questionnaire at the end of each use of the condition. Again, the most common area of thermal discomfort was the front and back torso where condition A had the hottest rating compared to all other conditions. However, the difference between the conditions was relatively small and it can be assumed that the thermal comfort of all conditions was relatively similar. There were no other areas of the body that were significantly affected by the thermal comfort of the conditions. In terms of physical discomfort the areas of discomfort were similar to Phase 1 where they were more spread out to include the front and back torso, arms, shoulders, hips, and neck. Condition A had the most accounts of physical discomfort followed by B, D, N_{final}, and G. Participants also assessed the comfort of the systems by subjectively providing a rating of comfort on a 200 point scale. All conditions received ratings in the comfortable range but condition A was found to be significantly less comfortable than conditions B, G, and N_{final}. When participants were asked to evaluate the comfort of the conditions over a range of factors it was found that condition A was harder, stiffer, thicker, and heavier than all other conditions.

5.1.3 Combined Overall Results

Figure 8 presents the final overall subjective rating of each condition for both Phase 1 and Phase 1a. In general all conditions were in the acceptable range (greater than 4), with the exception of condition A from Phase 1a and condition $N_{initial}$ in Phase 1. The following sections discuss the planned comparisons and other interesting findings, considering both Phase 1 and Phase 1a.

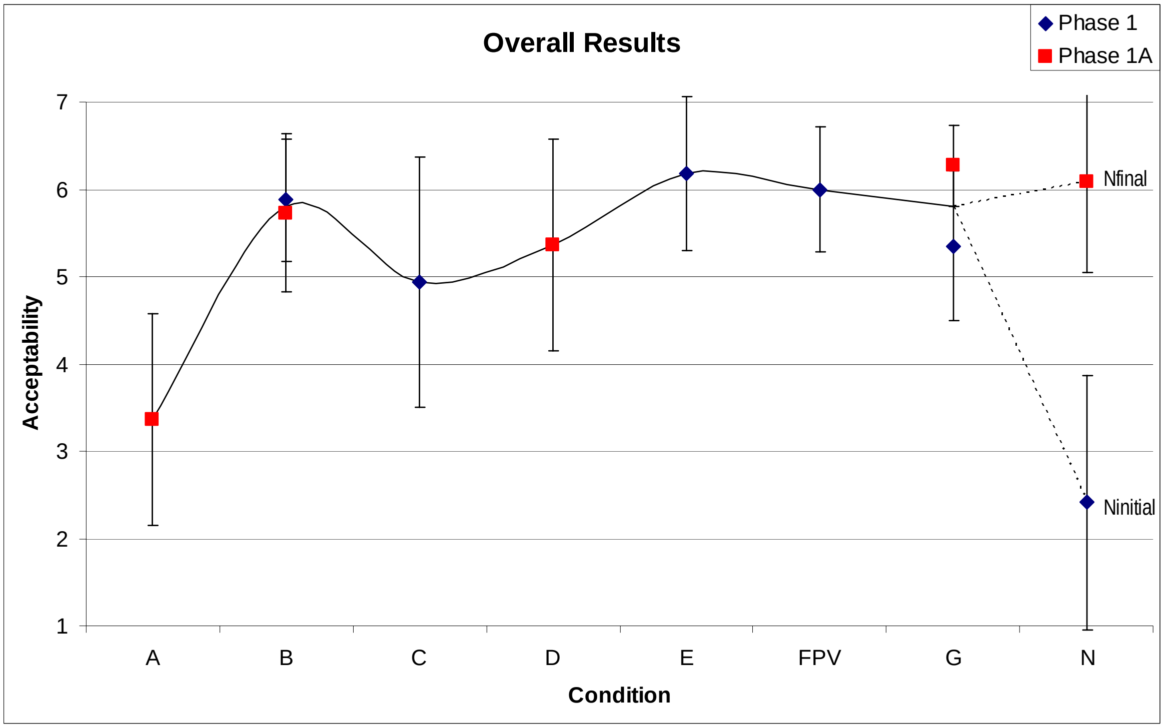


Figure 8: Collated Overall Results from Phase 1 and Phase 1a

5.2 Planned Comparisons

From the vulnerability and lethality analysis performed by DRDC Valcartier, a number of comparisons of interest emerged. The vulnerability and lethality analysis identified conditions that are similar in some instances but different in others. This allows us to examine the soldier's preferences to certain attributes in soft body armour. The armour conditions tested in these trials attempted to represent trade-offs of different factors. These comparisons sought to identify which factors are the most predictive of soldier acceptance of soft armour.

5.2.1 Bulk and Stiffness (A vs. B vs. C)

One of the planned comparisons of this study was to examine the impact of soft armour bulk, and stiffness on soldier acceptance. Conditions A, B, and C gave approximately equal levels of protection and weight by varying the two factors, with A being bulkier, and C being stiffer fill packs. From Phase 1, condition B was generally more acceptable than condition C. From Phase 1a, condition B is significantly more acceptable than condition A. Therefore, it appears that bulk is a more detrimental factor to soldier acceptance than stiffness. During the Phase 1a focus group, participants were asked which of these criteria were most important to them. 64% of the participants indicated flexibility/stiffness, 27% indicated bulk. This is contrary to the trial findings which indicated bulk was more important than stiffness.

There are several notable caveats to this comparison. The objective differences between these materials have not been measured. While condition A was designed to be bulkier, it is not known

objectively how much bulkier it is than the other conditions and likewise with the stiffness of condition C. Participants perceived intended differences in stiffness between conditions A and B favouring condition B but the actual differences in stiffness between the two are unknown. Therefore, while the absolute differences between conditions along these factors are not known, the participants do not appear to be keenly sensitive to individual factors.

All conditions were tested using the same armour cut and MTBAS carrier systems. While this was an important standardization of test conditions, the bulk of condition A made it very tight fitting in the armour pockets. This tight fit of the MTBAS carrier around the condition A armour seemed to create a stiffness that was not present in either the condition A armour or MTBAS carrier alone.

Finally, the trials gave a very limited duration of exposure to each armour condition. Participants' impressions of the relative importance of these factors may change with longer duration test.

5.2.2 Areal Density and Protection (B vs. D vs. E vs. G)

A number of armour conditions varied in areal density and level of protection. Conditions B and D offered comparable areal density, but greater perforation performance for some fragments, to condition G. Condition E offered comparable perforation performance for selected fragments, but lower areal density and a finer weave, compared to condition G. The added protection of condition B over condition G did not appear to adversely impact soldier acceptance. However, something about condition D caused a slight trend towards lower acceptance than condition G. Condition E was marginally more acceptable than condition G, with participants in Phase 1 indicating that while both were very acceptable, condition E was preferred. Therefore, areal density has a moderate predictive value of soldier acceptance of soft armour. There seems, however, to be another factor not accounted for in measures of areal density that influenced soldier acceptance as strongly as areal density. Note that condition B used a lighter hard armour plate than conditions D, E, and G.

5.2.3 Novel Concept Armour Cut (Phase 1 $N_{initial}$ vs. Phase 1a N_{final})

The incorrect armour cut of condition $N_{initial}$ in Phase 1 actually served as a control condition when examining the impact of the novel concept of armour cut. During Phase 1, condition $N_{initial}$ was not cut properly and as a result the KM2 400 material and Spectra Shield material were layered together throughout the entire vest, groin protector, brassard, and throat protector. This resulted in a bulkier, stiffer, and heavier armour fill pack. The added bulk, stiffness, and weight resulted in the condition being found unacceptable. This novel concept was intended to use a matrix protection approach, with less protection in the extremities, along the bottom of the vest, and in the shoulder area focusing the highest levels of fragment protection (i.e. armour mass, soft and hard) over the vital organs. Before introducing condition N_{final} to Phase 1a, the Spectra Shield material was cut down to cover approximately eighty percent of the torso area covered by the KM2 400 material. Furthermore when condition N_{final} was introduced to Phase 1a, only the KM2 400 material was used in the accessory protection (neck, throat, groin, and brassards). The participant groups of Phase 1 and 1a gave comparable results for conditions B and G. The differences between conditions $N_{initial}$ and N_{final} in phases 1 and 1a are remarkable. By modifying the stiffness, weight, and bulk of the armour in key areas around the shoulders and waist, and in the accessory protection, the acceptability of the armour fill pack went from clearly unacceptable to clearly acceptable. Condition N_{inital} went from the least acceptable system in all evaluation criteria in Phase 1 to among the most acceptable system in Phase 1a with N_{final}. This evidence supports the validation of the novel concept armour cut.

5.2.4 Increased Area of Coverage and Modified Carrier Design (FPV vs. G)

The inclusion of the FPV in Phase 1 as a control condition served to ensure that the different armour cut and carrier design of the MTBAS system did not adversely impact the results. In general, performance of conditions tested using the MTBAS carrier (B, C, E, G, $N_{initial}$) compared well to the FPV condition. The differences between MTBAS conditions and the FPV condition included the additional armour in arm brassards, throat guard, and groin guard, differences in the armour cut pattern, and differences in the carrier design, most notably the cummerbund system of the MTBAS. Condition G utilized the same soft armour material as the FPV. Participants indicated a slight preference for the FPV over the MTBAS with condition G; however, this difference was non-significant in both objective and subjective measures. Comparisons of other conditions using the MTBAS carrier ranged from condition E, which participants' comments indicated was marginally preferable to the FPV, to condition $N_{initial}$, which subjective measures and focus group discussions indicated was significantly worse than the FPV. Participants generally preferred the new carrier system over the current FPV, mainly due to the integration of the cummerbund system. The cummerbund redistributes the weight of the vest around the participant's waist and produces a better balanced fit. During focus group discussions the majority of participants indicated that they would choose the MTBAS carrier over the current issue FPV.

5.3 Limitations

No study is without limitations. One limitation of this trial was the participants. Due to unavailability of regular force soldiers, reserve force soldiers who typically have less experience and training were used. Also, all but one of the participants were male and as a result, the female CF population was not adequately represented. Furthermore, not all participants were available to complete all test conditions due to various reasons such as illness and injury. As a result, all of these participants' data was excluded from the analyses.

The validity of comparing small independent experimental groups, as in Phase 1 to Phase 1a comparisons, is questionable. This concern was mitigated by the inclusion of two reference conditions, B and G, to ensure that perceptions of participants in both groups were similar.

As discussed in the comparison of bulk, weight, and stiffness there are a number of caveats to the findings. The objective differences between materials have not been measured. The tight fit of the MTBAS carrier around the condition A armour seemed to create a stiffness that was not present in either the condition A armour or MTBAS carrier alone.

The very limited duration of exposure to each armour condition in these trials is also a limiting factor. Participants' impressions of the acceptability of different conditions and relative importance of evaluation factors may change with a longer duration test.

This page intentionally left blank.

6 Recommendations

For the Horizon 0 Phase 1 and 1a PPE trials, the following recommendations can be taken. In general, bulk, and to a lesser extent stiffness, are more important factors to consider than weight when predicting soldier acceptance of soft armour systems. Further study is needed to more clearly differentiate this trade-off and to determine at what point (e.g. beyond a certain weight) the criteria of importance changes.

The areal density of the soft armour material appears to be a good predictor of soldier acceptance; however, at least one other factor is playing a role in influencing soldier's perception. Again, further study with materials varying in different measurable material properties should allow better understanding, and predictors, of soldier acceptance of soft armour systems.

The novel concept of using a matrix of APLs dependent on the body area shows good promise. Results from the modified cut of condition N armour from Phase 1 to Phase 1a provides preliminary evidence in validating this novel concept as a way of increasing protection without negatively impacting soldier acceptance.

The lack of differences seen between the FPV condition and conditions using the MTBAS system suggest that accessory armour can be added with little to no cost in soldier acceptance if the appropriate soft armour material is chosen and the design is implemented correctly. This supports CF efforts to up-armour soldiers for specific crew positions and tasks where warranted by operational requirements. Furthermore the good performance of conditions B and N, which offered superior protection, in reference to the in-service material (condition G), suggests that soldier acceptance is not a barrier to more protective armour, provided it is implemented correctly.

6.1 Phase 2

As the C-IED PPE Horizon 0 moves to Phase 2 of user trials, the emphasis will shift to extremity soft armour and rigid armour. The project will need to choose a soft armour material for the torso that balances soldier acceptance and protection levels. While condition E was the most preferred armour type for a torso system, in re-testing other soft armour materials for the extremities it is important not to create the unrealistic situation whereby greater protection is offered on the extremities than on the torso. With this trade-off in mind, condition B appears to be the optimal choice of the conditions tested for torso armour to maximize both soldier acceptance and protection.

By extrapolating results from the Phase 1 and 1a, hypotheses regarding the acceptability of Phase 2 soft armour can be generated. It is anticipated that conditions C and D will be less acceptable than conditions B and G, which in turn will be less acceptable than conditions E and F (a new condition consisting of 10 plies of KM2 400).

The findings of Phase 1 and 1a also show that the subjective ratings of soldier's perceptions were the most diagnostic tool in measuring soldier acceptance. Objective measures of performance did not have the resolution necessary to detect differences between armour conditions. However, it is recommended that both subjective and objective measures are taken in Phase 2 for consistency and to allow comparison to Phase 1 and 1a results.

This page intentionally left blank.

References

Chamberland, A., Carrier, R., Forest, F., and Hachez, G. (1997). Anthropometric Survey of the Land Forces, DCIEM Report No. 98-CR-15.

This page intentionally left blank.

Annex A: Trial Questionnaires

This page intentionally left blank.

HORIZON 0

CONDITION QUESTIONNAIRE

NAME		DATE	

ARMOUR (circle one)	A	B	C	D	E	G	N	FPV

SIZE (circle one)	Medium Short	Medium Regular	Large Regular	Large Tall

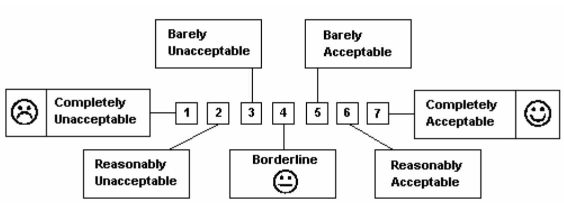
EXERTION - COMPLETE IMMEDIATELY FOLLOWING THE ASSAULT COURSE

Please rate (circle) your level of perceived exertion during the Assault Course using the scale provided below where 6 represents just above resting level of exertion and 20 represents maximal exertion.

Exertion	RPE
no exertion at all	6
extremely light	7
	8
very light	9
	10
light	11
	12
somewhat hard	13
	14
hard (heavy)	15
	16
very hard	17
	18
extremely hard	19
maximal exertion	20

Annex A:
Trial Questionnaires

Rate the acceptability of the fill packs for each criteria:



	☹ 1	2	3	😐 4	5	6	☺ 7
Fit	O	O	O	O	O	O	O
Ease of Assembly	O	O	O	O	O	O	O
Stability	O	O	O	O	O	O	O
Brassard Weight	O	O	O	O	O	O	O
Overall Weight	O	O	O	O	O	O	O
Flexibility / Stiffness	O	O	O	O	O	O	O
Thickness	O	O	O	O	O	O	O
Bulk	O	O	O	O	O	O	O
Range of Motion - Trunk Forward Flexion	O	O	O	O	O	O	O
Range of Motion - Trunk Lateral Flexion	O	O	O	O	O	O	O
Range of Motion - Trunk Rotation	O	O	O	O	O	O	O
Range of Motion - Shoulder Adduction (arm across body)	O	O	O	O	O	O	O
Range of Motion - Shoulder Flexion (arm over head)	O	O	O	O	O	O	O
Range of Motion - Hip Flexion	O	O	O	O	O	O	O
Overall Range of Motion	O	O	O	O	O	O	O
Breathing Constriction	O	O	O	O	O	O	O
Pressure Points	O	O	O	O	O	O	O
Chaffing	O	O	O	O	O	O	O
Overall Physical Comfort	O	O	O	O	O	O	O
Hot Spots	O	O	O	O	O	O	O
Ventilation	O	O	O	O	O	O	O
Overall Thermal Comfort	O	O	O	O	O	O	O
Compatibility - C7	O	O	O	O	O	O	O
Compatibility - C9	O	O	O	O	O	O	O
Compatibility - C6	O	O	O	O	O	O	O
Compatibility - M72	O	O	O	O	O	O	O
Compatibility - Carl Gustav	O	O	O	O	O	O	O
Compatibility - Driving Vehicles	O	O	O	O	O	O	O
Compatibility - Turret Gunner	O	O	O	O	O	O	O
Compatibility - Tactical Assault Vest	O	O	O	O	O	O	O
Compatibility - Ruck Sack	O	O	O	O	O	O	O
Compatibility - Small Pack	O	O	O	O	O	O	O
Compatibility - Clothing	O	O	O	O	O	O	O
Fire Positions - Standing	O	O	O	O	O	O	O
Fire Positions - Kneeling	O	O	O	O	O	O	O
Fire Positions - Prone	O	O	O	O	O	O	O
Mobility - Climbing	O	O	O	O	O	O	O
Mobility - Crawling	O	O	O	O	O	O	O
Mobility - Throwing	O	O	O	O	O	O	O
Mobility - Twisting	O	O	O	O	O	O	O
OVERALL RATING	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMFORT

Rate the comfort of the armour based on the CALM rating scale, using the 200-point scale below by simply placing a hash mark somewhere between +100 to -100 on the vertical line.

Error! Objects cannot be created from editing field codes.

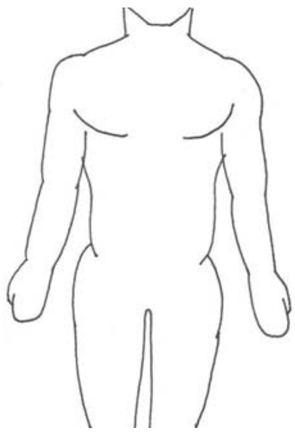
Please read the following list of characteristics and indicate which descriptor of each scale *best describes* the armour fill pack. The midpoint (4) of each scale represents "neither" position for the particular scale.

	1	2	3	4 (Neither)	5	6	7	
Warm	O	O	O	O	O	O	O	Cool
Damp	O	O	O	O	O	O	O	Dry
Hard	O	O	O	O	O	O	O	Soft
Stiff	O	O	O	O	O	O	O	Flexible
Rough	O	O	O	O	O	O	O	Smooth
Clean	O	O	O	O	O	O	O	Fuzzy
Thick	O	O	O	O	O	O	O	Thin
Heavy	O	O	O	O	O	O	O	Light
Loose	O	O	O	O	O	O	O	Dense
Non stretchy	O	O	O	O	O	O	O	Very Stretchy
Noisy	O	O	O	O	O	O	O	Quiet

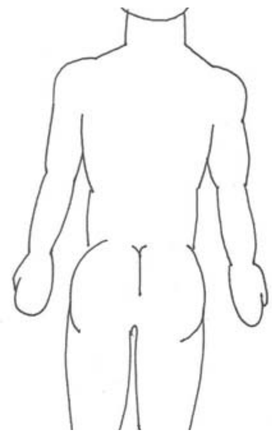
Annex A:
Trial Questionnaires

PHYSICAL DISCOMFORT				
Using the different views of the torso below, draw in the areas where you feel physical discomfort. Indicate how much discomfort with a number from the scale to the right.	**Neutral** 1	**Slight Discomfort** 2	**Noticeable Discomfort** 3	**Pain** 4

FRONT

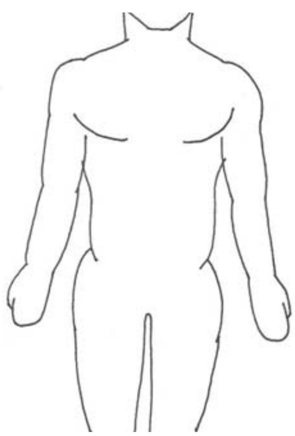


BACK

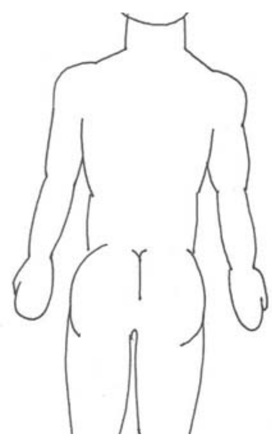


THERMAL DISCOMFORT				
Using the different views of the torso below, draw in the areas where you feel thermal discomfort. Indicate how much discomfort with a number from the scale to the right.	**Neutral** 1	**Slightly Warm** 2	**Noticeably Warm** 3	**Hot** 4

FRONT



BACK

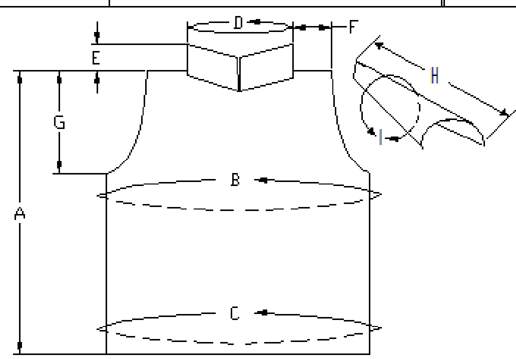


COMMENTS:

HORIZON 0 - FIT

NAME		**DATE**		
SIZE	Medium Short	Medium Regular	Large Regular	Large Tall

Rate the fit of the ***armour carrier and armour cut*** in the following dimensions:	**Fit Acceptance** ☹ 1	2	3	😐 4	5	6	☺ 7	**Fit Sizing** ☹ Short Small Tight	😐	☺	😐	☹ Long Large Loose
Vest Length (A)	O	O	O	O	O	O	O	O	O	O	O	O
Chest Girth (B)	O	O	O	O	O	O	O	O	O	O	O	O
Waist Girth (C)	O	O	O	O	O	O	O	O	O	O	O	O
Neck Opening (D)	O	O	O	O	O	O	O	O	O	O	O	O
Collar Height (E)	O	O	O	O	O	O	O	O	O	O	O	O
Width at Shoulder (F)	O	O	O	O	O	O	O	O	O	O	O	O
Arm Opening (G)	O	O	O	O	O	O	O	O	O	O	O	O
Brassard Length (H)	O	O	O	O	O	O	O	O	O	O	O	O
Brassard Girth (I)	O	O	O	O	O	O	O	O	O	O	O	O
Front Plate Pocket	O	O	O	O	O	O	O	O	O	O	O	O
Side Plate Pocket	O	O	O	O	O	O	O	O	O	O	O	O
Rear Plate Pocket	O	O	O	O	O	O	O	O	O	O	O	O
FINAL FIT	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**



Comments:

This page intentionally left blank.

HORIZON 0 - EXIT QUESTIONNAIRE

NAME			**DATE**	
SIZE (circle one)	Medium Short	Medium Regular	Large Regular	Large Tall

Rate the fill packs for each criteria:	A	B	C	D	E	G	N	FPV
	☹ 😐 ☺	☹ 😐 ☺	☹ 😐 ☺	☹ 😐 ☺	☹ 😐 ☺	☹ 😐 ☺	☹ 😐 ☺	☹ 😐 ☺
	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Range of Motion	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Mobility	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Bulk	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Weight	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Flexibility	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Comfort	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Compatibility	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
Overall	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O

Comments:

This page intentionally left blank.

Annex B: Statistical Results Details

Variable	Friedman ANOVA and Kendall Coeff. of Cc ANOVA Chi Sqr. (N = 20, df = 5) = 23.7632 Coeff. of Concordance = .23763 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Warm/Cool	4.425000	88.50000	3.352941	1.167146
Var2	3.475000	69.50000	3.058824	1.356101
Var3	3.900000	78.00000	3.157895	1.088851
Var4	3.650000	73.00000	3.117647	1.118380
Var5	3.375000	67.50000	2.888889	0.717370
Var6	2.175000	43.50000	2.166667	0.743392

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 20, df = 5) = 4.029228 Coeff. of Concordance = .04029 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Damp/Dry	3.875000	77.50000	3.823529	1.495090
Var8	3.475000	69.50000	3.647059	1.484700
Var9	3.825000	76.50000	3.684211	1.452860
Var10	3.450000	69.00000	3.529412	1.380985
Var11	3.325000	66.50000	3.500000	0.931891
Var12	3.050000	61.00000	3.166667	0.986754

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 20, df = 5) = 40.71189 Coeff. of Concordance = .40712 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Hard/Soft	4.225000	84.50000	4.000000	1.076055
Var14	2.650000	53.00000	2.941176	1.049842
Var15	4.900000	98.00000	4.842105	1.308400
Var16	3.175000	63.50000	3.470588	1.219044
Var17	4.100000	82.00000	3.888889	0.911268
Var18	1.950000	39.00000	2.555556	1.086870

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 20, df = 5) = 38.31 Coeff. of Concordance = .38319 Aver. rar			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Stiff/Flexible	4.275000	85.50000	4.176471	0.985970
Var20	3.025000	60.50000	3.176471	1.224113
Var21	4.775000	95.50000	4.736842	1.116484
Var22	3.250000	65.00000	3.529412	1.261480
Var23	3.925000	78.50000	3.833333	1.038724
Var24	1.750000	35.00000	2.166667	1.038724

Phase 1 Statistical Results

Variable	Friedman ANOVA and Kendall Coeff. (ANOVA Chi Sqr. (N = 20, df = 5) = 19. Coeff. of Concordance = .19263 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of Rough/ Smooth	3.700000	74.00000	4.235294	1.0527
Var26	3.150000	63.00000	3.764706	0.8902
Var27	4.175000	83.50000	4.368421	1.0367
Var28	3.250000	65.00000	4.000000	1.1239
Var29	4.275000	85.50000	4.352941	0.7211
Var30	2.450000	49.00000	3.222222	1.4347

Variable	Friedman ANOVA and Kendall Coeff. of (ANOVA Chi Sqr. (N = 20, df = 5) = 4.417(Coeff. of Concordance = .04418 Aver. ra			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Clean/ Fuzzy	3.225000	64.50000	3.588235	1.126654
Var32	3.250000	65.00000	3.705882	0.843845
Var33	3.675000	73.50000	3.947368	1.571914
Var34	3.200000	64.00000	3.470588	0.979669
Var35	3.625000	72.50000	3.722222	1.066502
Var36	4.025000	80.50000	4.166667	1.630305

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 20, df = 5) = 26.2674 Coeff. of Concordance = .26267 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Thick/ Thin	3.900000	78.00000	3.647059	1.121145
Var38	3.325000	66.50000	3.411765	0.976504
Var39	4.400000	88.00000	4.000000	1.123903
Var40	3.350000	67.00000	3.352941	0.790814
Var41	4.075000	81.50000	3.833333	0.931891
Var42	1.950000	39.00000	2.555556	1.346427

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 20, df = 5) = 44.382 Coeff. of Concordance = .44383 Aver. rar			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Heavy/ Light	3.875000	77.50000	3.823529	0.742350
Var44	3.050000	61.00000	3.470588	1.081794
Var45	4.250000	85.00000	4.157895	1.039390
Var46	4.475000	89.50000	4.117647	1.164490
Var47	3.950000	79.00000	4.000000	1.213954
Var48	1.400000	28.00000	2.166667	1.135550

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 20, df = 5) = 19.378 Coeff. of Concordance = .19379 Aver. ran			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Loose/Dense	3.325000	66.50000	4.588235	1.028992
Var50	2.850000	57.00000	4.529412	0.733962
Var51	2.675000	53.50000	4.526316	1.186256
Var52	4.150000	83.00000	5.000000	0.794719
Var53	3.650000	73.00000	4.722222	0.711230
Var54	4.350000	87.00000	5.277778	1.289862

Variable	Friedman ANOVA and Ker ANOVA Chi Sqr. (N = 20, (Coeff. of Concordance = .1		
	Average Rank	Sum of Ranks	Mea
Sum of Non-Stretchy/VeryStretchy	4.050000	81.00000	4.176
Var56	2.750000	55.00000	3.352
Var57	3.650000	73.00000	4.000
Var58	3.800000	76.00000	4.000
Var59	4.050000	81.00000	4.111
Var60	2.700000	54.00000	3.444

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 20, df = 5) = 3.18669 Coeff. of Concordance = .03187 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Noisy/Quiet	3.600000	72.00000	5.176471	1.266379
Var62	3.725000	74.50000	5.352941	1.254095
Var63	3.800000	76.00000	5.315789	1.378505
Var64	3.500000	70.00000	5.117647	1.251624
Var65	3.300000	66.00000	5.055556	1.356164
Var66	3.075000	61.50000	4.833333	1.135550

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 19, df = 5) = 51.23878 Coeff. of Concordance = .53936 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of G-Wagon	4.868421	92.50000	6.909774	0.533377
Var2	2.631579	50.00000	5.928571	1.176827
Var3	4.315789	82.00000	6.933333	0.847655
Var4	3.868421	73.50000	6.590643	0.478341
Var5	3.894737	74.00000	6.500000	0.833333
Var6	1.421053	27.00000	4.352941	1.488518

Variable	Friedman ANOVA and Kendall Coeff. of Concord ANOVA Chi Sqr. (N = 19, df = 5) = 38.63139 p < Coeff. of Concordance = .40665 Aver. rank r = .3			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of LSVW	4.157895	79.00000	6.533835	0.745116
Var8	2.500000	47.50000	5.714286	1.221501
Var9	4.421053	84.00000	6.600000	0.557773
Var10	4.394737	83.50000	6.532164	0.588620
Var11	3.684211	70.00000	6.166667	1.013794
Var12	1.842105	35.00000	4.764706	1.748949

Variable	Friedman ANOVA and Kendall Coeff. of Concord ANOVA Chi Sqr. (N = 19, df = 5) = 35.98266 p < Coeff. of Concordance = .37876 Aver. rank r = .3			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of MLVW	4.052632	77.00000	6.609023	0.583391
Var14	3.026316	57.50000	6.000000	1.000000
Var15	4.289474	81.50000	6.666667	0.544331
Var16	4.263158	81.00000	6.649123	0.464462
Var17	3.710526	70.50000	6.222222	1.082977
Var18	1.657895	31.50000	4.764706	1.616904

Variable	Friedman ANOVA and Kendall Coeff. of Concorda ANOVA Chi Sqr. (N = 18, df = 5) = 48.54130 p < .(Coeff. of Concordance = .53935 Aver. rank r = .51			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of ROM	4.305556	77.50000	5.764706	0.729981
Var2	2.972222	53.50000	4.764706	1.351662
Var3	4.305556	77.50000	5.944444	0.998365
Var4	4.666667	84.00000	6.166667	0.985184
Var5	3.611111	65.00000	5.388889	0.916444
Var6	1.138889	20.50000	2.611111	1.419979

Variable	Friedman ANOVA and Kendall Coeff. of Conco ANOVA Chi Sqr. (N = 18, df = 5) = 51.94004 p Coeff. of Concordance = .57711 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Mobility	4.027778	72.50000	5.882353	0.757888
Var8	3.000000	54.00000	5.000000	1.533930
Var9	4.333333	78.00000	6.055556	0.998365
Var10	4.916667	88.50000	6.500000	0.707107
Var11	3.638889	65.50000	5.555556	1.149026
Var12	1.083333	19.50000	2.611111	1.419979

Variable	Friedman ANOVA and Kendall Coeff. of Concorda ANOVA Chi Sqr. (N = 18, df = 5) = 49.28161 p < .0 Coeff. of Concordance = .54757 Aver. rank r = .52			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Bulk	4.055556	73.00000	5.882353	0.962983
Var14	3.250000	58.50000	5.411765	1.140631
Var15	4.388889	79.00000	6.277778	0.894792
Var16	4.750000	85.50000	6.333333	0.840168
Var17	3.333333	60.00000	5.277778	1.227410
Var18	1.222222	22.00000	2.722222	1.637989

Variable	Friedman ANOVA and Kendall Coeff. of Concor ANOVA Chi Sqr. (N = 18, df = 5) = 56.33065 p Coeff. of Concordance = .62590 Aver. rank r = .			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Weight	4.388889	79.00000	6.176471	0.784804
Var20	3.416667	61.50000	5.411765	1.717002
Var21	4.222222	76.00000	6.166667	0.985184
Var22	4.583333	82.50000	6.333333	0.840168
Var23	3.361111	60.50000	5.555556	1.096638
Var24	1.027778	18.50000	2.222222	1.262843

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 18, df = 5) = 46.64522 Coeff. of Concordance = .51828 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Flexibility	4.111111	74.00000	5.529412	0.848365
Var26	3.055556	55.00000	4.529412	1.613095
Var27	4.527778	81.50000	5.944444	0.937595
Var28	4.305556	77.50000	5.611111	1.036901
Var29	3.833333	69.00000	5.277778	1.127494
Var30	1.166667	21.00000	2.444444	1.381484

Variable	Friedman ANOVA and Kendall Coeff. of Conco ANOVA Chi Sqr. (N = 18, df = 5) = 43.29787 p Coeff. of Concordance = .48109 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Comfort	4.166667	75.00000	6.058824	0.638987
Var32	3.333333	60.00000	5.352941	1.369464
Var33	4.555556	82.00000	6.388889	0.697802
Var34	3.944444	71.00000	5.833333	1.043185
Var35	3.750000	67.50000	5.722222	1.074055
Var36	1.250000	22.50000	2.833333	1.723539

Variable	Friedman ANOVA and Kendall Coeff. of ANOVA Chi Sqr. (N = 18, df = 5) = 50.98 Coeff. of Concordance = .56648 Aver. ra			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Compatibility	4.166667	75.00000	5.823529	0.70588
Var38	3.000000	54.00000	4.941176	1.51349
Var39	4.555556	82.00000	6.111111	0.90025
Var40	4.500000	81.00000	6.055556	0.72535
Var41	3.638889	65.50000	5.444444	0.98352
Var42	1.138889	20.50000	2.666667	1.45521

Variable	Friedman ANOVA and Kendall Coeff. of Conco ANOVA Chi Sqr. (N = 18, df = 5) = 49.69147 p Coeff. of Concordance = .55213 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Overall	4.222222	76.00000	5.882353	0.675831
Var44	2.972222	53.50000	4.941176	1.392019
Var45	4.722222	85.00000	6.222222	0.878204
Var46	4.416667	79.50000	6.000000	0.685994
Var47	3.472222	62.50000	5.444444	0.921777
Var48	1.194444	21.50000	2.500000	1.465285

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 20, df = 5) = 51.39262 Coeff. of Concordance = .51393 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Throwing	4.175000	83.50000	6.058824	0.685994
Var2	2.900000	58.00000	5.294118	1.064484
Var3	4.725000	94.50000	6.421053	1.042052
Var4	4.275000	85.50000	6.166667	1.088214
Var5	3.600000	72.00000	5.823529	0.810152
Var6	1.325000	26.50000	4.044118	1.261173

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 48.06189 p Coeff. of Concordance = .48062 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Twisting	4.375000	87.50000	6.176471	0.485071
Var8	3.000000	60.00000	5.588235	0.861994
Var9	4.475000	89.50000	6.223684	0.895124
Var10	4.325000	86.50000	6.222222	1.054093
Var11	3.500000	70.00000	5.882353	0.639272
Var12	1.325000	26.50000	3.985294	1.321119

Variable	Friedman ANOVA and Kendall Coeff. of ANOVA Chi Sqr. (N = 20, df = 5) = 54.7 Coeff. of Concordance = .54756 Aver. r			
	Average Rank	Sum of Ranks	Mean	Std.Dev
Sum of Overall Rating	4.250000	85.00000	6.058824	0.68599
Var14	2.975000	59.50000	5.588235	0.92103
Var15	4.250000	85.00000	6.118421	0.64298
Var16	4.600000	92.00000	6.277778	0.63291
Var17	3.650000	73.00000	5.888889	0.71737
Var18	1.275000	25.50000	3.972222	1.39705

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 20, df = 5) = 43.387 Coeff. of Concordance = .43387 Aver. ran			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Driving Veh.	4.200000	84.00000	6.500000	0.648886
Var164	2.200000	44.00000	5.470588	1.081794
Var165	4.200000	84.00000	6.578947	0.674013
Var166	4.425000	88.50000	6.666667	0.648886
Var167	3.900000	78.00000	6.388889	0.803865
Var168	2.075000	41.50000	4.833333	1.980165

Variable	Friedman ANOVA and Kendall Coeff. of ANOVA Chi Sqr. (N = 20, df = 5) = 30.8 Coeff. of Concordance = .30811 Aver. r			
	Average Rank	Sum of Ranks	Mean	Std.Dev
Sum of Turret Gunner	3.775000	75.50000	6.470588	0.65835
Var170	2.700000	54.00000	5.941176	1.19078
Var171	4.075000	81.50000	6.736842	0.96475
Var172	4.350000	87.00000	6.777778	0.61177
Var173	3.925000	78.50000	6.529412	0.80247
Var174	2.175000	43.50000	5.437500	1.62120

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 16.41917 Coeff. of Concordance = .16419 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Standing	3.100000	62.00000	5.764706	1.148427
Var176	3.600000	72.00000	6.000000	1.025978
Var177	4.550000	91.00000	6.789474	1.360300
Var178	3.825000	76.50000	6.166667	1.038724
Var179	3.300000	66.00000	5.882353	0.966946
Var180	2.625000	52.50000	5.352941	2.050447

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 19.67626 Coeff. of Concordance = .19676 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Kneeling	3.525000	70.50000	5.764706	0.829040
Var182	2.925000	58.50000	5.294118	1.513612
Var183	4.275000	85.50000	6.000000	1.213954
Var184	4.125000	82.50000	5.944444	1.145803
Var185	3.800000	76.00000	5.882353	1.019925
Var186	2.350000	47.00000	4.666667	2.271100

Variable	Friedman ANOVA and Kendall Coeff. of Concord ANOVA Chi Sqr. (N = 20, df = 5) = 29.52847 p < Coeff. of Concordance = .29528 Aver. rank r = .2			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Prone	3.850000	77.00000	6.352941	0.721196
Var188	2.950000	59.00000	6.000000	0.725476
Var189	4.575000	91.50000	6.736842	0.784193
Var190	3.700000	74.00000	6.333333	0.794719
Var191	3.950000	79.00000	6.388889	0.735483
Var192	1.975000	39.50000	4.833333	2.108878

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 40.53265 Coeff. of Concordance = .40533 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Climbing	3.850000	77.00000	6.176471	0.667698
Var194	3.075000	61.50000	5.705882	1.013836
Var195	4.325000	86.50000	6.578947	1.310516
Var196	4.150000	83.00000	6.333333	0.917663
Var197	4.125000	82.50000	6.187500	0.741176
Var198	1.475000	29.50000	4.470588	1.838697

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 42.83051 Coeff. of Concordance = .42831 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Crawling	4.100000	82.00000	6.294118	0.539464
Var200	3.000000	60.00000	5.647059	1.022956
Var201	4.425000	88.50000	6.421053	0.815365
Var202	4.475000	89.50000	6.500000	0.931891
Var203	3.475000	69.50000	5.941176	1.145728
Var204	1.525000	30.50000	4.529412	1.780528

Variable	Friedman ANOVA and Kendall Coef ANOVA Chi Sqr. (N = 20, df = 5) = 5 Coeff. of Concordance = .51636 Ave Average Rank	Sum of Ranks	Mean	Std.I
Sum of ROM- Tr. Lat Flex	4.025000	80.50000	5.941176	0.68
Var56	2.625000	52.50000	5.176471	0.93
Var57	4.700000	94.00000	6.315789	1.02
Var58	4.600000	92.00000	6.222222	0.69
Var59	3.550000	71.00000	5.555556	0.80
Var60	1.500000	30.00000	4.111111	1.80

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 20, df = 5) = 48.511 Coeff. of Concordance = .48511 Aver. rar Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of ROM- Tr. Rot	3.950000	79.00000	5.941176	0.758849
Var62	2.675000	53.50000	5.235294	1.001547
Var63	4.475000	89.50000	6.368421	1.345970
Var64	4.775000	95.50000	6.333333	0.648886
Var65	3.550000	71.00000	5.555556	0.871914
Var66	1.575000	31.50000	4.111111	1.888717

Variable	Friedman ANOVA and Kendall Coeff. c ANOVA Chi Sqr. (N = 20, df = 5) = 47.9 Coeff. of Concordance = .47904 Aver. Average Rank	Sum of Ranks	Mean	Std.De
Sum of ROM- Sho. Add	4.400000	88.00000	6.000000	0.7254
Var68	2.800000	56.00000	5.294118	0.9605
Var69	4.350000	87.00000	6.105263	1.2521
Var70	4.450000	89.00000	6.111111	0.6398
Var71	3.475000	69.50000	5.500000	0.8111
Var72	1.525000	30.50000	4.055556	1.8770

Variable	Friedman ANOVA and Kendall Coeff. c ANOVA Chi Sqr. (N = 20, df = 5) = 46.4 Coeff. of Concordance = .46410 Aver. Average Rank	Sum of Ranks	Mean	Std.De
Sum of ROM- Sh. Flex.	4.450000	89.00000	6.058824	0.7588
Var74	2.650000	53.00000	5.235294	1.0015
Var75	4.375000	87.50000	6.157895	1.1361
Var76	4.625000	92.50000	6.222222	0.6924
Var77	3.100000	62.00000	5.388889	0.8038
Var78	1.800000	36.00000	4.411765	1.7489

Variable	Friedman ANOVA and Kendall Coeff. o ANOVA Chi Sqr. (N = 20, df = 5) = 51.7 Coeff. of Concordance = .51724 Aver. r			
	Average Rank	Sum of Ranks	Mean	Std.Dev
Sum of ROM- Hip Flex	3.825000	76.50000	5.823529	0.74235
Var80	2.600000	52.00000	5.176471	0.87270
Var81	4.525000	90.50000	6.368421	1.34597
Var82	4.900000	98.00000	6.444444	0.66666
Var83	3.550000	71.00000	5.666667	0.79471
Var84	1.600000	32.00000	4.166667	1.89875

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 20, df = 5) = 53.571 Coeff. of Concordance = .53571 Aver. rar			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Overall ROM	3.900000	78.00000	5.941176	0.758849
Var86	2.800000	56.00000	5.294118	0.960521
Var87	4.575000	91.50000	6.368421	1.133719
Var88	4.600000	92.00000	6.277778	0.632918
Var89	3.750000	75.00000	5.666667	0.973329
Var90	1.375000	27.50000	3.833333	1.813691

Variable	Friedman ANOVA and Kendall ANOVA Chi Sqr. (N = 20, df = 5 Coeff. of Concordance = .3045		
	Average Rank	Sum of Ranks	Mean
Sum of Breathing Constriction	4.175000	83.50000	6.058824
Var92	3.025000	60.50000	5.588235
Var93	4.475000	89.50000	6.315789
Var94	3.800000	76.00000	5.888889
Var95	3.550000	71.00000	5.666667
Var96	1.975000	39.50000	4.722222

Variable	Friedman ANOVA and Kendall Coeff. o ANOVA Chi Sqr. (N = 20, df = 5) = 24. Coeff. of Concordance = .24794 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of Pressure Points	4.250000	85.00000	6.352941	0.6440
Var98	2.825000	56.50000	5.647059	0.9142
Var99	4.125000	82.50000	6.368421	0.7405
Var100	4.100000	82.00000	6.277778	0.7112
Var101	3.500000	70.00000	5.944444	1.0989
Var102	2.200000	44.00000	4.944444	2.0123

Variable	Friedman ANOVA and Kenc ANOVA Chi Sqr. (N = 20, df Coeff. of Concordance = .41		
	Average Rank	Sum of Ranks	Mean
Sum of Overall Physical Comfort	4.675000	93.50000	6.4117
Var104	2.750000	55.00000	5.5882
Var105	4.125000	82.50000	6.3684
Var106	3.850000	77.00000	6.0000
Var107	3.875000	77.50000	6.0555
Var108	1.725000	34.50000	4.7777

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 21.40684 p Coeff. of Concordance = .21407 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Chaffing	4.375000	87.50000	6.705882	0.539464
Var110	3.275000	65.50000	6.176471	0.810152
Var111	3.575000	71.50000	6.315789	1.028675
Var112	3.525000	70.50000	6.222222	0.948991
Var113	4.050000	81.00000	6.388889	1.033079
Var114	2.200000	44.00000	5.277778	2.021088

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 39.04401 p Coeff. of Concordance = .39044 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Exertion	2.325000	46.5000	11.76471	2.373747
Var2	4.050000	81.0000	13.11765	2.552241
Var3	3.225000	64.5000	13.05263	4.173522
Var4	2.650000	53.0000	11.83333	2.518354
Var5	3.275000	65.5000	12.44444	2.299250
Var6	5.475000	109.5000	16.16667	3.937004

Variable	Friedman ANOVA and Kendall Coeff. of Concordanc ANOVA Chi Sqr. (N = 20, df = 5) = 17.72643 p < .00 Coeff. of Concordance = .17726 Aver. rank r = .1339			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Fit	3.325000	66.50000	5.941176	0.886779
Var8	2.800000	56.00000	5.705882	0.843845
Var9	4.375000	87.50000	6.526316	1.271900
Var10	4.125000	82.50000	6.166667	0.668856
Var11	3.700000	74.00000	6.000000	0.725476
Var12	2.675000	53.50000	5.444444	1.841688

Variable	Friedman ANOVA and Kendall Coef ANOVA Chi Sqr. (N = 20, df = 5) = 4 Coeff. of Concordance = .40480 Ave			
	Average Rank	Sum of Ranks	Mean	Std.I
Sum of Ease of Assembly	3.400000	68.0000	5.882353	0.85
Var14	2.475000	49.5000	5.529412	0.57
Var15	4.100000	82.0000	6.105263	0.71
Var16	5.050000	101.0000	6.611111	0.66
Var17	3.625000	72.5000	5.944444	0.82
Var18	2.350000	47.0000	5.444444	2.00

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 20, df = 5) = 28.20000 p Coeff. of Concordance = .28200 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Stability	3.675000	73.50000	6.058824	0.944267
Var20	2.850000	57.00000	5.941176	0.604421
Var21	4.200000	84.00000	6.684211	1.452860
Var22	4.475000	89.50000	6.470588	0.658359
Var23	3.575000	71.50000	6.111111	0.639810
Var24	2.225000	44.50000	5.588235	1.488865

Variable	Friedman ANOVA and Kendall Coeff. ANOVA Chi Sqr. (N = 20, df = 5) = 37 Coeff. of Concordance = .37619 Aver			
	Average Rank	Sum of Ranks	Mean	Std.D
Sum of Brassard Weight	3.725000	74.50000	6.235294	0.609
Var26	2.925000	58.50000	5.941176	0.758
Var27	4.325000	86.50000	6.684211	1.523
Var28	4.125000	82.50000	6.352941	0.644
Var29	4.150000	83.00000	6.388889	0.574
Var30	1.750000	35.00000	4.944444	1.790

Variable	Friedman ANOVA and Kendall Coeff. c ANOVA Chi Sqr. (N = 20, df = 5) = 43.: Coeff. of Concordance = .43131 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of Overall Weight	3.775000	75.50000	5.941176	0.8252
Var32	2.975000	59.50000	5.529412	0.8655
Var33	4.525000	90.50000	6.368421	0.8712
Var34	4.500000	90.00000	6.277778	0.6329
Var35	3.625000	72.50000	5.833333	0.8735
Var36	1.600000	32.00000	3.888889	1.8321

Variable	Friedman ANOVA and Kendall Cc ANOVA Chi Sqr. (N = 20, df = 5) = Coeff. of Concordance = .58652 A			
	Average Rank	Sum of Ranks	Mean	St
Sum of Flexibility/ Stiffness	4.775000	95.5000	6.000000	0.
Var38	2.600000	52.0000	4.812500	0.
Var39	5.000000	100.0000	6.263158	1.
Var40	3.775000	75.5000	5.500000	0.
Var41	3.400000	68.0000	5.277778	0.
Var42	1.450000	29.0000	3.333333	1.

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 20, df = 5) = 44.73773 Coeff. of Concordance = .44738 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Thickness	4.075000	81.5000	5.823529	0.872703
Var44	2.550000	51.0000	5.058824	0.825297
Var45	5.000000	100.0000	6.421053	0.935599
Var46	4.175000	83.5000	5.888889	0.911268
Var47	3.325000	66.5000	5.222222	1.102894
Var48	1.875000	37.5000	3.833333	1.813691

Variable	Friedman ANOVA and Kendall Coeff. ANOVA Chi Sqr. (N = 20, df = 5) = 52 Coeff. of Concordance = .52425 Aver			
	Average Rank	Sum of Ranks	Mean	Std.D
Sum of ROM-Tr For Flex	3.950000	79.00000	5.941176	0.825
Var50	2.650000	53.00000	5.235294	0.947
Var51	4.600000	92.00000	6.368421	1.133
Var52	4.775000	95.50000	6.277778	0.711
Var53	3.550000	71.00000	5.555556	0.809
Var54	1.475000	29.50000	4.166667	1.662

Variable	Friedman ANOVA and Kendall Coef ANOVA Chi Sqr. (N = 20, df = 5) = 5 Coeff. of Concordance = .51636 Ave			
	Average Rank	Sum of Ranks	Mean	Std.I
Sum of ROM- Tr. Lat Flex	4.025000	80.50000	5.941176	0.68
Var56	2.625000	52.50000	5.176471	0.93
Var57	4.700000	94.00000	6.315789	1.02
Var58	4.600000	92.00000	6.222222	0.69
Var59	3.550000	71.00000	5.555556	0.80
Var60	1.500000	30.00000	4.111111	1.80

Variable	Friedman ANOVA and Kendall Coeff. of Concordance ((ANOVA Chi Sqr. (N = 20, df = 5) = 39.02332 p < .00000 Coeff. of Concordance = .39023 Aver. rank r = .35814			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Fill	4.275000	85.50000	47.41176	16.14428
Var2	2.875000	57.50000	22.05882	32.18609
Var3	4.575000	91.50000	51.31579	26.63408
Var4	3.950000	79.00000	45.72222	20.72833
Var5	3.875000	77.50000	41.94444	28.87810
Var6	1.450000	29.00000	-9.77778	39.22614

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 58.30565 p < .00000 Coeff. of Concordance = .58306 Aver. rank r = .56111			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C7A1 Prone	4.000000	80.00000	6.235294	0.609522
Var2	2.575000	51.50000	5.437500	0.723206
Var3	4.775000	95.50000	6.631579	0.581335
Var4	4.175000	83.50000	6.312500	0.704777
Var5	4.225000	84.50000	6.333333	0.648886
Var6	1.250000	25.00000	3.666667	1.589439

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 40.77974 p < .00000 Coeff. of Concordance = .40780 Aver. rank r = .37663			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C7A1 Kneeling	3.600000	72.00000	5.294118	0.843845
Var8	2.775000	55.50000	4.750000	1.235442
Var9	4.450000	89.00000	5.789474	1.195560
Var10	4.450000	89.00000	5.687500	0.901388
Var11	4.125000	82.50000	5.611111	0.866869
Var12	1.600000	32.00000	3.111111	1.552210

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 47.73984 p < .00000 Coeff. of Concordance = .47740 Aver. rank r = .44989			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C7A1 Standing	3.475000	69.50000	5.117647	0.910890
Var14	2.400000	48.00000	4.562500	0.856477
Var15	4.650000	93.00000	6.105263	1.585949
Var16	4.625000	92.50000	5.875000	0.786398
Var17	4.125000	82.50000	5.500000	0.931891
Var18	1.725000	34.50000	3.277778	1.549382

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 48.38867 p < .00000 Coeff. of Concordance = .48389 Aver. rank r = .45672			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C9	3.700000	74.00000	6.235294	0.690493
Var20	3.150000	63.00000	6.000000	0.917663
Var21	4.700000	94.00000	6.894737	1.118963
Var22	4.075000	81.50000	6.437500	0.646346
Var23	3.900000	78.00000	6.333333	0.794719
Var24	1.475000	29.50000	4.111111	1.743828

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 51.96768 p < .00000 Coeff. of Concordance = .51968 Aver. rank r = .49440			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C6	3.900000	78.00000	6.176471	1.037979
Var26	3.050000	61.00000	5.750000	1.147079
Var27	4.250000	85.00000	6.684211	1.172161
Var28	4.450000	89.00000	6.562500	0.646346
Var29	4.025000	80.50000	6.333333	0.917663
Var30	1.325000	26.50000	4.000000	1.622214

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 21.93515 p < .00054 Coeff. of Concordance = .21935 Aver. rank r = .17826			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of M72	3.825000	76.50000	6.470588	0.658359
Var32	3.000000	60.00000	6.250000	0.760886
Var33	4.050000	81.00000	6.842105	1.386520
Var34	4.150000	83.00000	6.687500	0.425348
Var35	3.700000	74.00000	6.500000	0.584898
Var36	2.275000	45.50000	5.833333	0.931891

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 13.43049 p < .01966 Coeff. of Concordance = .13430 Aver. rank r = .08874			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Carl G.	3.575000	71.50000	6.529412	0.472134
Var38	3.375000	67.50000	6.437500	0.915869
Var39	4.125000	82.50000	6.842105	1.181576
Var40	3.450000	69.00000	6.375000	0.716350
Var41	3.925000	78.50000	6.611111	0.574812
Var42	2.550000	51.00000	5.888889	1.333333

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_csc) ANOVA Chi Sqr. (N = 20, df = 5) = 13.04303 p < .02298 Coeff. of Concordance = .13043 Aver. rank r = .08466			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of Pistol	3.675000	73.50000	6.437500	0.792647
Var44	3.125000	62.50000	6.142857	0.965573
Var45	4.200000	84.00000	6.842105	1.423974
Var46	2.700000	54.00000	6.000000	1.123903
Var47	4.000000	80.00000	6.555556	0.741423
Var48	3.300000	66.00000	6.187500	0.985086

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 9.00000 Coeff. of Concordance = .20455 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of warm/cool	2.181818	24.00000	1.909091	0.700649
Var2	2.772727	30.50000	2.363636	0.809040
Var3	2.909091	32.00000	2.363636	1.026911
Var4	3.590909	39.50000	2.909091	1.136182
Var5	3.545455	39.00000	2.909091	1.300350

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 11, df = 4) = 6.097902 Coeff. of Concordance = .13859 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of damp/dry	2.409091	26.50000	2.727273	1.190874
Var7	2.772727	30.50000	3.090909	1.700267
Var8	2.863636	31.50000	3.090909	1.136182
Var9	3.363636	37.00000	3.545455	1.507557
Var10	3.590909	39.50000	3.636364	1.501514

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 14.82927 p Coeff. of Concordance = .33703 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of hard/soft	1.772727	19.50000	3.181818	1.662419
Var12	3.318182	36.50000	4.454545	1.128152
Var13	2.681818	29.50000	3.818182	1.470930
Var14	3.454545	38.00000	4.727273	1.272078
Var15	3.772727	41.50000	5.000000	1.000000

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 20.0705 Coeff. of Concordance = .45615 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of stiff/flexible	1.454545	16.00000	2.818182	1.662419
Var17	3.318182	36.50000	4.727273	1.555050
Var18	2.818182	31.00000	4.181818	1.328020
Var19	3.636364	40.00000	5.090909	1.375103
Var20	3.772727	41.50000	5.181818	1.078720

Variable	Friedman ANOVA and Kendall Coeff. of ANOVA Chi Sqr. (N = 11, df = 4) = 15.33 Coeff. of Concordance = .34859 Aver. ra			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of rough/smooth	2.045455	22.50000	3.454545	1.12815
Var22	2.818182	31.00000	4.363636	0.80904
Var23	2.636364	29.00000	4.272727	0.64667
Var24	3.772727	41.50000	4.818182	0.87386
Var25	3.727273	41.00000	4.909091	0.94388

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 10, df = 4) = 3.71653 Coeff. of Concordance = .09291 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of clean/fuzzy	3.550000	35.50000	3.200000	1.229273
Var27	3.000000	30.00000	3.100000	1.100505
Var28	3.150000	31.50000	3.200000	0.788811
Var29	2.550000	25.50000	2.900000	0.875595
Var30	2.750000	27.50000	3.000000	0.816497

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 32.66667 Coeff. of Concordance = .74242 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of thick/thin	1.000000	11.00000	1.636364	0.809040
Var32	3.090909	34.00000	4.363636	1.566699
Var33	2.727273	30.00000	4.363636	1.026911
Var34	4.181818	46.00000	5.636364	1.026911
Var35	4.000000	44.00000	5.545455	0.934199

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 32.5800 Coeff. of Concordance = .74045 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of heavy/light	1.090909	12.00000	2.909091	0.943880
Var37	3.136364	34.50000	4.818182	1.250454
Var38	2.454545	27.00000	4.363636	0.924416
Var39	3.954545	43.50000	5.454545	0.687552
Var40	4.363636	48.00000	5.818182	0.603023

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 11, df = 4) = 2.7111 Coeff. of Concordance = .06162 Aver. ran			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of loose/dense	3.500000	38.50000	4.636364	1.286291
Var42	2.772727	30.50000	4.363636	0.809040
Var43	2.590909	28.50000	4.090909	0.943880
Var44	2.954545	32.50000	4.272727	1.103713
Var45	3.181818	35.00000	4.272727	1.190874

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 8.15384 Coeff. of Concordance = .18531 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of non/stretch	2.181818	24.00000	3.727273	0.904534
Var47	3.318182	36.50000	4.363636	0.924416
Var48	2.863636	31.50000	4.272727	0.786245
Var49	3.545455	39.00000	4.545455	0.522233
Var50	3.090909	34.00000	4.272727	0.786245

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 10.4935 Coeff. of Concordance = .23849 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of noisy/quiet	2.136364	23.50000	4.909091	1.044466
Var52	3.590909	39.50000	5.545455	0.934199
Var53	2.545455	28.00000	5.090909	1.044466
Var54	3.136364	34.50000	5.363636	1.120065
Var55	3.590909	39.50000	5.545455	1.035725

Tukey HSD test; variable Avg Forward Flexion (ROM)
Approximate Probabilities for Post Hoc Tests
Error: Between MS = 9963.6, df = 50.000

Cell No.	Fill Pack	{1} 26.559	{2} 25.295	{3} 26.655	{4} 28.045
1	G		1.000000	1.000000	1.000000
2	D	1.000000		1.000000	0.999996
3	B	1.000000	1.000000		1.000000
4	N	1.000000	0.999996	1.000000	
5	A	0.562841	0.544076	0.564260	0.584954

Tukey HSD test; variable Avg Forward Flexion (ROM)
Approximate Probabilities for Post Hoc Tests
Error: Between MS = 9963.6, df = 50.000

Cell No.	Fill Pack	{1} 26.559	{2} 25.295	{3} 26.655	{4} 28.045
1	G		1.000000	1.000000	1.000000
2	D	1.000000		1.000000	0.999996
3	B	1.000000	1.000000		1.000000
4	N	1.000000	0.999996	1.000000	
5	A	0.562841	0.544076	0.564260	0.584954

Tukey HSD test; variable Tr. Lateral Flexion (ROM)
Approximate Probabilities for Post Hoc Tests
Error: Between MS = 46.113, df = 50.000

Cell No.	Fill Pack	{1} 39.500	{2} 40.955	{3} 40.864	{4} 35.773
1	G		0.986825	0.989694	0.700192
2	D	0.986825		1.000000	0.391019
3	B	0.989694	1.000000		0.409028
4	N	0.700192	0.391019	0.409028	
5	A	0.992080	0.879144	0.891600	0.914268

Tukey HSD test; variable Arm Adduction (ROM)
Approximate Probabilities for Post Hoc Tests
Error: Between MS = 33.861, df = 50.000

Cell No.	Fill Pack	{1} 111.23	{2} 110.73	{3} 111.00	{4} 109.77
1	G		0.999658	0.999985	0.976589
2	D	0.999658		0.999969	0.995271
3	B	0.999985	0.999969		0.987573
4	N	0.976589	0.995271	0.987573	
5	A	0.692074	0.806185	0.746207	0.952280

Cell No.	Tukey HSD test; variable Tr. Rotation (ROM) Approximate Probabilities for Post Hoc Tests Error: Between MS = 118.38, df = 50.000 Fill Pack	{1} 40.045	{2} 39.727	{3} 38.136	{4} 41.273
1	G		0.999995	0.993844	0.998942
2	D	0.999995		0.996988	0.997309
3	B	0.993844	0.996988		0.960752
4	N	0.998942	0.997309	0.960752	
5	A	0.854470	0.883644	0.976349	0.714182

Cell No.	Tukey HSD test; variable Hip Flexion (ROM) Approximate Probabilities for Post Hoc Tests Error: Between MS = 24.025, df = 50.000 Fill Pack	{1} 67.636	{2} 68.318	{3} 67.455	{4} 67.955
1	G		0.997519	0.999988	0.999888
2	D	0.997519		0.993745	0.999809
3	B	0.999988	0.993745		0.999311
4	N	0.999888	0.999809	0.999311	
5	A	0.741136	0.898707	0.689511	0.823110

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (I ANOVA Chi Sqr. (N = 11, df = 4) = 25.93035 p < .00003 Coeff. of Concordance = .58933 Aver. rank r = .54826			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A rom	1.090909	12.00000	3.272727	1.103713
B rom	3.500000	38.50000	5.818182	0.981650
D rom	2.727273	30.00000	5.181818	1.250454
G rom	3.863636	42.50000	6.181818	0.750757
N rom	3.818182	42.00000	6.090909	1.044466

Variable	Friedman ANOVA and Kendall Coeff. of Concordanc ANOVA Chi Sqr. (N = 11, df = 4) = 28.08290 p < .00(Coeff. of Concordance = .63825 Aver. rank r = .6020			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A mobility	1.045455	11.50000	3.363636	1.286291
B mobility	3.727273	41.00000	6.090909	0.831209
D mobility	2.727273	30.00000	5.454545	1.213560
G mobility	3.590909	39.50000	6.181818	0.404520
N mobility	3.909091	43.00000	6.272727	1.009050

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (I ANOVA Chi Sqr. (N = 11, df = 4) = 31.84615 p < .00000 Coeff. of Concordance = .72378 Aver. rank r = .69615			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A bulk	1.000000	11.00000	2.363636	0.924416
B bulk	3.136364	34.50000	5.636364	0.809040
D bulk	2.909091	32.00000	5.454545	1.128152
G bulk	4.136364	45.50000	6.272727	0.904534
N bulk	3.818182	42.00000	6.272727	0.646670

Variable	Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 11, df = 4) = 30.15556 p < .000(Coeff. of Concordance = .68535 Aver. rank r = .65389			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A weight	1.000000	11.00000	3.363636	1.206045
B weight	3.500000	38.50000	5.909091	1.300350
D weight	2.909091	32.00000	5.545455	1.213560
G weight	3.590909	39.50000	6.000000	1.000000
N weight	4.000000	44.00000	6.454545	0.687552

Phase 1a Statistical Results

Variable	Friedman ANOVA and Kendall Coeff. of Concordar ANOVA Chi Sqr. (N = 11, df = 4) = 24.83146 p < .0(Coeff. of Concordance = .56435 Aver. rank r = .520			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A flexibility	1.272727	14.00000	3.636364	1.286291
B flexibility	3.363636	37.00000	5.818182	0.873863
D flexibility	2.727273	30.00000	5.363636	1.206045
G flexibility	3.954545	43.50000	6.181818	0.873863
N flexibility	3.681818	40.50000	6.000000	1.095445

Variable	Friedman ANOVA and Kendall Coeff. of Concordanc ANOVA Chi Sqr. (N = 11, df = 4) = 21.25641 p < .00(Coeff. of Concordance = .48310 Aver. rank r = .4314			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A Comfort	1.454545	16.00000	4.090909	1.814086
B Comfort	3.590909	39.50000	6.090909	1.221028
D Comfort	2.818182	31.00000	5.636364	1.120065
G Comfort	3.636364	40.00000	6.181818	0.750757
N Comfort	3.500000	38.50000	6.181818	0.873863

Variable	Friedman ANOVA and Kendall Coeff. of Conco ANOVA Chi Sqr. (N = 11, df = 4) = 27.81053 p Coeff. of Concordance = .63206 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A Compatibility	1.090909	12.00000	2.909091	1.221028
B Compatibility	3.409091	37.50000	5.727273	1.272078
D Compatibility	2.727273	30.00000	5.363636	0.924416
G Compatibility	3.909091	43.00000	6.181818	0.603023
N Compatiblity	3.863636	42.50000	6.000000	1.183216

Variable	Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 11, df = 4) = 26.76923 p < .000 Coeff. of Concordance = .60839 Aver. rank r = .56923			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
A Overall	1.090909	12.00000	3.363636	1.206045
B Overall	3.409091	37.50000	5.727273	0.904534
D Overall	2.772727	30.50000	5.363636	1.206045
G Overall	4.000000	44.00000	6.272727	0.467099
N Overall	3.727273	41.00000	6.090909	1.044466

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 11, df = 4) = 19.64286 Coeff. of Concordance = .44643 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of prone fire	1.454545	16.00000	3.909091	1.578261
Var157	3.000000	33.00000	5.636364	1.120065
Var158	3.136364	34.50000	5.727273	1.272078
Var159	3.772727	41.50000	6.272727	0.904534
Var160	3.636364	40.00000	6.181818	0.750757

Variable	Friedman ANOVA and Kendall Coeff. of Concord ANOVA Chi Sqr. (N = 11, df = 4) = 15.36986 p < Coeff. of Concordance = .34932 Aver. rank r = .2			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of climb	1.681818	18.50000	4.545455	1.572491
Var162	3.454545	38.00000	6.272727	0.467099
Var163	3.000000	33.00000	6.000000	0.632456
Var164	3.409091	37.50000	6.181818	0.750757
Var165	3.454545	38.00000	6.181818	0.873863

Variable	Friedman ANOVA and Kendall Coeff. of Concord ANOVA Chi Sqr. (N = 11, df = 4) = 21.61151 p < Coeff. of Concordance = .49117 Aver. rank r = .4			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of crawl	1.454545	16.00000	4.181818	1.601136
Var167	3.454545	38.00000	6.272727	0.646670
Var168	3.090909	34.00000	6.000000	0.894427
Var169	3.500000	38.50000	6.272727	0.646670
Var170	3.500000	38.50000	6.272727	0.646670

Variable	Friedman ANOVA and Kendall Coeff. of Concord ANOVA Chi Sqr. (N = 11, df = 4) = 25.16049 p < Coeff. of Concordance = .57183 Aver. rank r = .5			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of throw	1.363636	15.00000	4.363636	1.286291
Var172	3.636364	40.00000	6.000000	1.095445
Var173	2.636364	29.00000	5.454545	0.820200
Var174	3.863636	42.50000	6.272727	0.786245
Var175	3.500000	38.50000	6.181818	0.603023

Variable	Friedman ANOVA and Kendall Coeff. of Concorda ANOVA Chi Sqr. (N = 11, df = 4) = 16.80537 p < .0 Coeff. of Concordance = .38194 Aver. rank r = .32			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of twist	1.681818	18.50000	4.363636	1.501514
Var177	3.500000	38.50000	5.909091	0.831209
Var178	2.772727	30.50000	5.545455	0.820200
Var179	3.500000	38.50000	6.000000	0.632456
Var180	3.545455	39.00000	6.181818	0.873863

Variable	Friedman ANOVA and Kendall Coeff. of Concor ANOVA Chi Sqr. (N = 11, df = 4) = 21.43590 p < Coeff. of Concordance = .48718 Aver. rank r = .			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of overall	1.590909	17.50000	4.272727	1.737292
Var182	3.590909	39.50000	6.000000	1.183216
Var183	2.500000	27.50000	5.545455	0.687552
Var184	3.636364	40.00000	6.181818	0.404520
Var185	3.681818	40.50000	6.090909	1.136182

Variable	Friedman ANOVA and Kendall Coeff. (ANOVA Chi Sqr. (N = 11, df = 4) = 11. Coeff. of Concordance = .26033 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of breath constrict	1.909091	21.00000	5.181818	1.2504
Var87	3.227273	35.50000	6.090909	0.8312
Var88	3.136364	34.50000	6.181818	0.6030
Var89	3.500000	38.50000	6.272727	0.4670
Var90	3.227273	35.50000	6.090909	0.8312

Variable	Friedman ANOVA and Kendall Coeff. of Conco ANOVA Chi Sqr. (N = 11, df = 4) = 5.552239 p Coeff. of Concordance = .12619 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of chaffing	2.272727	25.00000	5.545455	1.293340
Var92	3.409091	37.50000	6.363636	0.674200
Var93	3.136364	34.50000	6.272727	0.646670
Var94	3.227273	35.50000	6.363636	0.674200
Var95	2.954545	32.50000	6.181818	0.750757

Variable	Friedman ANOVA and Kendall Coef ANOVA Chi Sqr. (N = 11, df = 4) = 1 Coeff. of Concordance = .39851 Ave			
	Average Rank	Sum of Ranks	Mean	Std.
Sum of overall phys comf	1.772727	19.50000	4.727273	1.48
Var97	3.681818	40.50000	6.272727	0.78
Var98	2.590909	28.50000	5.727273	0.90
Var99	3.636364	40.00000	6.272727	0.46
Var100	3.318182	36.50000	6.000000	1.09

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 9, df = 4) = 7.852941 p Coeff. of Concordance = .21814 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of hot spots	2.111111	19.00000	4.333333	1.581139
Var102	3.666667	33.00000	5.555556	1.424001
Var103	2.611111	23.50000	4.888889	1.269296
Var104	3.111111	28.00000	5.111111	1.364225
Var105	3.500000	31.50000	5.333333	1.322876

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 8.58333 Coeff. of Concordance = .19508 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of ventilation	2.181818	24.00000	4.000000	1.341641
Var107	3.636364	40.00000	5.000000	1.264911
Var108	2.818182	31.00000	4.363636	1.501514
Var109	2.954545	32.50000	4.727273	1.272078
Var110	3.409091	37.50000	4.818182	0.981650

Variable	Friedman ANOVA and Kendall Co ANOVA Chi Sqr. (N = 11, df = 4) = Coeff. of Concordance = .20794 A			
	Average Rank	Sum of Ranks	Mean	Std
Sum of overall therm comf	1.954545	21.50000	4.000000	1.6
Var112	3.500000	38.50000	5.181818	1.4
Var113	2.863636	31.50000	4.727273	1.4
Var114	3.500000	38.50000	5.090909	1.0
Var115	3.181818	35.00000	5.000000	1.0

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 27.1460 Coeff. of Concordance = .61696 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of c7 compat	1.136364	12.50000	3.636364	1.120065
Var117	3.636364	40.00000	6.181818	0.981650
Var118	2.772727	30.50000	5.454545	0.934199
Var119	3.772727	41.50000	6.363636	0.674200
Var120	3.681818	40.50000	6.363636	0.674200

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 22.0413 Coeff. of Concordance = .50094 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of c9 compat	1.409091	15.50000	4.454545	1.293340
Var122	3.409091	37.50000	6.090909	0.831209
Var123	3.090909	34.00000	6.000000	0.894427
Var124	3.545455	39.00000	6.181818	0.750757
Var125	3.545455	39.00000	6.272727	0.646670

Variable	Friedman ANOVA and Kendall Coeff. of Cor ANOVA Chi Sqr. (N = 11, df = 4) = 13.62222 Coeff. of Concordance = .30960 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of c6 compat	1.727273	19.00000	9.818182	17.66815
Var127	3.136364	34.50000	5.909091	0.94388
Var128	2.863636	31.50000	5.818182	0.98165
Var129	3.454545	38.00000	6.000000	0.89443
Var130	3.818182	42.00000	6.363636	0.50452

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 11, df = 4) = 15.250 Coeff. of Concordance = .34659 Aver. ran			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of m72 compat	1.909091	21.00000	5.636364	1.206045
Var132	3.318182	36.50000	6.545455	0.687552
Var133	3.318182	36.50000	6.545455	0.687552
Var134	3.136364	34.50000	6.454545	0.687552
Var135	3.318182	36.50000	6.363636	1.206045

Variable	Friedman ANOVA and Kendall Coeff. of Cor ANOVA Chi Sqr. (N = 10, df = 4) = 6.78260 Coeff. of Concordance = .16957 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of cg compat	2.150000	21.50000	5.300000	1.766981
Var137	3.200000	32.00000	6.100000	0.994429
Var138	3.350000	33.50000	6.000000	1.563472
Var139	3.300000	33.00000	6.300000	0.674949
Var140	3.000000	30.00000	6.000000	1.333333

Variable	Friedman ANOVA and Kendall Coeff. ANOVA Chi Sqr. (N = 6, df = 4) = 2.52 Coeff. of Concordance = .10539 Aver			
	Average Rank	Sum of Ranks	Mean	Std.D
Sum of clothing compat	2.583333	15.50000	5.833333	1.329
Var142	3.333333	20.00000	6.500000	0.547
Var143	2.583333	15.50000	6.000000	1.264
Var144	3.333333	20.00000	6.500000	0.547
Var145	3.166667	19.00000	6.500000	0.836

Variable	Friedman ANOVA and Kendall Coeff. of Cor ANOVA Chi Sqr. (N = 11, df = 4) = 14.7486(Coeff. of Concordance = .33520 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of c6 compat	1.681818	18.50000	4.636364	1.120065
Var127	3.136364	34.50000	5.909091	0.943880
Var128	2.863636	31.50000	5.818182	0.981650
Var129	3.454545	38.00000	6.000000	0.894427
Var130	3.863636	42.50000	6.363636	0.504525

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 28.81481 Coeff. of Concordance = .65488 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of stand fire	1.136364	12.50000	4.000000	1.183216
Var147	3.681818	40.50000	6.272727	0.904534
Var148	2.909091	32.00000	5.727273	1.272078
Var149	3.454545	38.00000	6.272727	0.646670
Var150	3.818182	42.00000	6.545455	0.522233

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 24.31707 Coeff. of Concordance = .55266 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of kneel fire	1.636364	18.00000	4.181818	1.537412
Var152	3.727273	41.00000	6.272727	0.646670
Var153	2.181818	24.00000	5.090909	1.221028
Var154	3.772727	41.50000	6.363636	0.674200
Var155	3.681818	40.50000	6.363636	0.504525

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 11, df = 4) = 19.64286 Coeff. of Concordance = .44643 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of prone fire	1.454545	16.00000	3.909091	1.578261
Var157	3.000000	33.00000	5.636364	1.120065
Var158	3.136364	34.50000	5.727273	1.272078
Var159	3.772727	41.50000	6.272727	0.904534
Var160	3.636364	40.00000	6.181818	0.750757

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 25.95960 p Coeff. of Concordance = .58999 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of exertion	4.636364	51.00000	14.09091	2.625054
Var2	2.954545	32.50000	11.90909	3.389824
Var3	3.545455	39.00000	12.54545	2.583162
Var4	2.090909	23.00000	11.27273	2.611165
Var5	1.772727	19.50000	10.63636	2.730301

Variable	Friedman ANOVA and Kendall Coeff. of Concordance ANOVA Chi Sqr. (N = 10, df = 4) = 13.46939 p < .009 Coeff. of Concordance = .33673 Aver. rank r = .2630			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of fit	1.850000	18.50000	5.000000	1.154701
Var7	3.900000	39.00000	6.400000	0.699206
Var8	2.700000	27.00000	5.700000	1.159502
Var9	3.500000	35.00000	6.200000	0.632456
Var10	3.050000	30.50000	5.900000	1.197219

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 11.74026 Coeff. of Concordance = .26682 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of assembly	1.818182	20.00000	4.272727	1.678744
Var12	3.545455	39.00000	5.636364	1.501514
Var13	3.363636	37.00000	5.636364	1.804036
Var14	3.181818	35.00000	5.636364	0.924416
Var15	3.090909	34.00000	5.454545	1.128152

Variable	Friedman ANOVA and Kendall Coeff. of Conco ANOVA Chi Sqr. (N = 11, df = 4) = 11.01333 p Coeff. of Concordance = .25030 Aver. rank r =			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of stability	1.909091	21.00000	5.272727	0.646670
Var17	3.590909	39.50000	6.090909	0.831209
Var18	2.954545	32.50000	5.818182	0.981650
Var19	3.181818	35.00000	5.909091	0.831209
Var20	3.363636	37.00000	6.090909	0.700649

Phase 1a Statistical Results

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 10, df = 4) = 17.1250 Coeff. of Concordance = .42812 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of brassard wt	2.050000	20.50000	5.200000	1.475730
Var22	3.750000	37.50000	6.400000	0.699206
Var23	2.150000	21.50000	5.600000	0.699206
Var24	3.550000	35.50000	6.300000	0.483046
Var25	3.500000	35.00000	6.300000	0.674949

Variable	Friedman ANOVA and Kendall Coeff. of Con ANOVA Chi Sqr. (N = 10, df = 4) = 18.41727 Coeff. of Concordance = .46043 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of overall wt	1.600000	16.00000	4.500000	1.581139
Var27	3.300000	33.00000	5.900000	1.197219
Var28	2.700000	27.00000	5.600000	1.429841
Var29	3.900000	39.00000	6.400000	0.516398
Var30	3.500000	35.00000	6.200000	0.632456

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 27.88372 Coeff. of Concordance = .63372 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of flexibility	1.454545	16.00000	3.909091	1.044466
Var32	3.136364	34.50000	5.545455	1.368476
Var33	2.363636	26.00000	5.000000	1.183216
Var34	4.181818	46.00000	6.181818	0.603023
Var35	3.863636	42.50000	6.090909	0.700649

Variable	Friedman ANOVA and Kendall Coeff. of Conc ANOVA Chi Sqr. (N = 11, df = 4) = 29.05263 Coeff. of Concordance = .66029 Aver. rank r			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of thickness	1.136364	12.50000	3.727273	1.272078
Var37	3.409091	37.50000	5.818182	1.250454
Var38	2.772727	30.50000	5.727273	0.904534
Var39	3.727273	41.00000	6.272727	0.904534
Var40	3.954545	43.50000	6.363636	0.674200

Variable	Friedman ANOVA and Kendall Coeff. of Concordai ANOVA Chi Sqr. (N = 11, df = 4) = 28.08791 p < .0 Coeff. of Concordance = .63836 Aver. rank r = .60:			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of bulk	1.136364	12.50000	3.636364	1.206045
Var42	3.409091	37.50000	5.636364	1.501514
Var43	2.772727	30.50000	5.363636	0.674200
Var44	4.136364	45.50000	6.272727	0.646670
Var45	3.545455	39.00000	5.818182	0.873863

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 11, df = 4) = 16.42: Coeff. of Concordance = .37326 Aver. rar			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of rom fwd flex	1.590909	17.50000	4.272727	1.103713
Var47	3.500000	38.50000	5.818182	0.873863
Var48	2.863636	31.50000	5.454545	1.128152
Var49	3.727273	41.00000	5.909091	0.700649
Var50	3.318182	36.50000	5.909091	0.831209

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 17.030(Coeff. of Concordance = .38706 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of rom lat flex	1.772727	19.50000	4.363636	1.361817
Var52	3.181818	35.00000	5.727273	1.103713
Var53	2.590909	28.50000	5.545455	0.522233
Var54	3.954545	43.50000	6.090909	0.700649
Var55	3.500000	38.50000	6.000000	0.894427

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 11, df = 4) = 15.224 Coeff. of Concordance = .34601 Aver. ran			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of rom rotation	1.681818	18.50000	4.454545	1.128152
Var57	3.409091	37.50000	5.818182	0.981650
Var58	2.863636	31.50000	5.545455	0.687552
Var59	3.772727	41.50000	5.909091	0.943880
Var60	3.272727	36.00000	5.909091	0.831209

Variable	Friedman ANOVA and Kendall Coeff. ANOVA Chi Sqr. (N = 11, df = 4) = 12 Coeff. of Concordance = .28631 Aver			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of rom shld abduct	1.818182	20.00000	4.272727	1.555
Var62	3.727273	41.00000	5.909091	0.943
Var63	2.727273	30.00000	5.272727	0.904
Var64	3.363636	37.00000	5.636364	1.120
Var65	3.363636	37.00000	5.909091	0.831

Variable	Friedman ANOVA and Kendall Coeff. of (ANOVA Chi Sqr. (N = 11, df = 4) = 21.43 Coeff. of Concordance = .48705 Aver. ra			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of rom shld flex	1.454545	16.00000	4.272727	1.190874
Var67	3.681818	40.50000	5.909091	0.831209
Var68	2.681818	29.50000	5.363636	1.120065
Var69	3.590909	39.50000	5.818182	0.873863
Var70	3.590909	39.50000	6.090909	0.831209

Variable	Friedman ANOVA and Kendall Coeff. of C ANOVA Chi Sqr. (N = 10, df = 4) = 10.014 Coeff. of Concordance = .25035 Aver. ran			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of rom hip flex	1.950000	19.50000	4.700000	1.418136
Var72	3.200000	32.00000	5.800000	0.918937
Var73	2.800000	28.00000	5.700000	0.823273
Var74	3.400000	34.00000	5.900000	0.737865
Var75	3.650000	36.50000	6.200000	0.788811

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 10, df = 4) = 16.8947 Coeff. of Concordance = .42237 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of overall rom	1.600000	16.00000	4.300000	1.337494
Var77	3.850000	38.50000	6.200000	0.788811
Var78	2.650000	26.50000	5.500000	0.849837
Var79	3.450000	34.50000	5.900000	0.737865
Var80	3.450000	34.50000	6.100000	0.875595

Variable	Friedman ANOVA and Kendall Coeff. of Co ANOVA Chi Sqr. (N = 11, df = 4) = 12.2682 Coeff. of Concordance = .27882 Aver. rank			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of pressure pt	2.136364	23.50000	5.363636	1.206045
Var82	3.909091	43.00000	6.636364	0.504525
Var83	2.454545	27.00000	5.818182	0.981650
Var84	3.454545	38.00000	6.272727	0.786245
Var85	3.045455	33.50000	6.000000	1.000000

Variable	Friedman ANOVA and Kendall Coeff. (ANOVA Chi Sqr. (N = 11, df = 4) = 11. Coeff. of Concordance = .26033 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of breath constrict	1.909091	21.00000	5.181818	1.2504
Var87	3.227273	35.50000	6.090909	0.8312
Var88	3.136364	34.50000	6.181818	0.6030
Var89	3.500000	38.50000	6.272727	0.4670
Var90	3.227273	35.50000	6.090909	0.8312

Variable	Friedman ANOVA and Kendall Coeff. (ANOVA Chi Sqr. (N = 11, df = 4) = 11. Coeff. of Concordance = .26033 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of breath constrict	1.909091	21.00000	5.181818	1.2504
Var87	3.227273	35.50000	6.090909	0.8312
Var88	3.136364	34.50000	6.181818	0.6030
Var89	3.500000	38.50000	6.272727	0.4670
Var90	3.227273	35.50000	6.090909	0.8312

Variable	Friedman ANOVA and Kendall Coeff. (ANOVA Chi Sqr. (N = 11, df = 4) = 11. Coeff. of Concordance = .26033 Aver.			
	Average Rank	Sum of Ranks	Mean	Std.De
Sum of breath constrict	1.909091	21.00000	5.181818	1.2504
Var87	3.227273	35.50000	6.090909	0.8312
Var88	3.136364	34.50000	6.181818	0.6030
Var89	3.500000	38.50000	6.272727	0.4670
Var90	3.227273	35.50000	6.090909	0.8312

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 25.85143 p < .00003 Coeff. of Concordance = .58753 Aver. rank r = .54629			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C7 STANDING	1.181818	13.00000	4.090909	1.044466
Var2	3.681818	40.50000	6.272727	1.190874
Var3	2.818182	31.00000	5.727273	1.009050
Var4	3.681818	40.50000	6.454545	0.687552
Var5	3.636364	40.00000	6.363636	0.674200

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 18.52023 p < .00098 Coeff. of Concordance = .42091 Aver. rank r = .36301			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C7 KNEELING	1.454545	16.00000	4.000000	1.414214
Var7	3.272727	36.00000	5.909091	0.539360
Var8	3.000000	33.00000	5.545455	1.213560
Var9	3.772727	41.50000	6.181818	0.981650
Var10	3.500000	38.50000	6.181818	0.603023

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 23.46667 p < .00010 Coeff. of Concordance = .53333 Aver. rank r = .48667			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C7 PRONE	1.272727	14.00000	3.727273	1.793929
Var12	3.363636	37.00000	6.181818	0.873863
Var13	3.090909	34.00000	5.909091	1.375103
Var14	3.818182	42.00000	6.545455	0.687552
Var15	3.454545	38.00000	6.454545	0.687552

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 11.86885 p < .01836 Coeff. of Concordance = .26975 Aver. rank r = .19672			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C6	1.772727	19.50000	4.545455	1.293340
Var17	3.181818	35.00000	5.818182	0.750757
Var18	2.909091	32.00000	5.545455	1.368476
Var19	3.727273	41.00000	6.181818	0.873863
Var20	3.409091	37.50000	5.909091	0.831209

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 19.86301 p < .00053 Coeff. of Concordance = .45143 Aver. rank r = .39658			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of C9	1.545455	17.00000	4.636364	1.286291
Var22	3.181818	35.00000	6.000000	0.774597
Var23	3.000000	33.00000	6.000000	1.000000
Var24	3.772727	41.50000	6.363636	0.809040
Var25	3.500000	38.50000	6.181818	0.603023

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 16.25397 p < .00270 Coeff. of Concordance = .36941 Aver. rank r = .30635			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of PISTOL	1.727273	19.00000	5.636364	0.924416
Var27	3.363636	37.00000	6.727273	0.467099
Var28	3.181818	35.00000	6.636364	0.674200
Var29	3.545455	39.00000	6.818182	0.404520
Var30	3.181818	35.00000	6.636364	0.674200

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_CSC) ANOVA Chi Sqr. (N = 11, df = 4) = 10.17476 p < .03759 Coeff. of Concordance = .23124 Aver. rank r = .15437			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of M72	2.136364	23.50000	5.636364	1.206045
Var32	3.045455	33.50000	6.454545	0.934199
Var33	3.136364	34.50000	6.545455	0.687552
Var34	3.545455	39.00000	6.727273	0.467099
Var35	3.136364	34.50000	6.545455	0.687552

Variable	Friedman ANOVA and Kendall Coeff. of Concordance (Weapons_ ANOVA Chi Sqr. (N = 11, df = 4) = 6.070922 p < .19392 Coeff. of Concordance = .13798 Aver. rank r = .05177			
	Average Rank	Sum of Ranks	Mean	Std.Dev.
Sum of CARL GUSTAV	2.454545	27.00000	5.727273	0.904534
Var37	3.045455	33.50000	6.090909	0.700649
Var38	3.136364	34.50000	5.909091	1.300350
Var39	3.681818	40.50000	6.454545	0.522233
Var40	2.681818	29.50000	5.818182	0.981650

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.) Publishing: DRDC Toronto Performing: Humansystems Inc., 111 Farquhar St., 2nd floor, Guelph, ON N1H 3N4 Monitoring: Contracting:	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title)

Counter−IED PPE Horizon 0; Phase 1 Human Factors Trial: Performance Evaluation of Soft Armour; Personal Protective Equipment (U)
Essai ergonomique du projet Horizon 0 d'EPI à l'épreuve des IED, phase 1: Evaluation du rendement d'un équipement de protection individuel en matériel souple (U)

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

Harry Angel; Chris Ste−Croix; Andrew Morton

5. DATE OF PUBLICATION (Month and year of publication of document.) March 2008	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 113	6b. NO. OF REFS (Total cited in document.) 1

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Contract Report

8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development − include address.)

Sponsoring: DLR−5, NDHQ Ottawa, ON K1A 0K2
Tasking: DRDC Valcartier

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.) 12RR	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.) W7711−078110/001/TOR
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document) DRDC Toronto CR 2009−036	10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (Any limitations on the dissemination of the document, other than those imposed by security classification.)

Unlimited distribution

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11), However, when further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited announcement

UNCLASSIFIED

DOCUMENT CONTROL DATA

(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

(U) The nature of the threat from Improvised Explosive Devices (IED) has changed the pattern and probability of injury for both mounted and dismounted personnel. The aim of the Horizon 0 Phase 1 and Phase 1a trials was to investigate the impact of various soft armour options on soldier mobility. The trials considered soldier task performance as well as soldier acceptance and comfort. The soft armour options varied in stiffness/flexibility, weight, bulk, and protection levels. Phase 1 was a five−day trial with twenty reserve soldiers and Phase 1a was a two day trial with eleven reserve soldiers. Participants undertook a battery of human factors tests while wearing test conditions in a repeated measures design. Fit, Range of Motion (ROM), discrete mobility, and compatibility test stands were conducted followed by dynamic assessments of mobility and agility. Data collection included questionnaires, focus groups, compatibility scores, performance measures, and Human Factors (HF) observer assessments. Test conditions used the Modular Tactical Body Armour System (MTBAS) armour carrier design, with modular add−on groin, neck, throat, and brassard protection. In general all conditions were in the acceptable range (greater than 4), with the exception of condition A (10 plies KM2 600 + 9 plies FR10 with 1.9 kg plates) from Phase 1a and condition Ninitial (2.1 kg/m2 KM2 400 (N1), 5.4 kg/m2 Spectra Shield SA−3118 (N3) with 1.4 kg plates) in Phase 1. It appears that bulk is a more detrimental factor to soldier acceptance than stiffness. Areal density has moderate predictive value of soldier acceptance of soft armour; however, there seems to be another factor not accounted for in measures of areal density influencing soldier acceptance as strongly as areal density. In Phase 1, Ninitial was constructed with overlapping fills N1 and N3. In Phase 1A, N1 kept the same shape, covering the entire torso, but the N3 fill was cut to only cover the central organs of the torso, leaving the sides, shoulder area, lower torso and neck region with the more flexible N1 fill. By reducing the stiffness, weight, and bulk of the armour in those key areas around the shoulders and waist, the acceptability of the armour fill pack N went from clearly unacceptable to clearly acceptable. The different armour cut and carrier design of the MTBAS system did not adversely impact the results. Limitations of findings due to participants, sample size, experimental conditions, limited exposure, and testing are discussed. General and Phase 2 user trial recommendations are provided.

(U) Par sa nature, la menace que posent les dispositifs explosifs de circonstance (IED pour improvised explosive devices) a modifié le type de blessure, et la probabilité de subir une blessure, auxquels s'exposent les militaires à pied ou à bord de véhicules. Les essais de phase 1 et de phase 1a du projet Horizon 0 avaient pour objet de scruter les effets de différentes options de blindage souple sur la mobilité des militaires, en tenant compte de leur rendement dans l'accomplissement de leurs tâches, de leur degré d'acceptation de l'équipement de protection individuel (EPI) et de leur confort. Les options de blindage souple comptaient différents degrés de rigidité/souplesse, de poids, de volume et de protection. La phase 1 a consisté en un essai de cinq jours mettant à contribution vingt réservistes et la phase 1a, en un essai de deux jours faisant appel à onze réservistes. Les participants, munis de divers EPI, ont subi une batterie de tests d'ergonomie observant une formule de répétition des mesures. Des bancs d'essai sur l'ajustement, l'amplitude de mouvement, la liberté de mouvement et la compatibilité ont été mis en œuvre et suivis d'évaluations dynamiques de la mobilité et de l'agilité. La cueillette de données s'est faite au moyen de questionnaires, de groupes de discussion, de notations de la compatibilité, de mesures du rendement et d'évaluations produites par des observateurs en ergonomie.

Les conditions d’essai ont eu recours au concept de protection que constitue le Système de gilet pare balles tactique modulaire (SGPBTM), avec protections modulaires amovibles pour l’aine, le cou, la gorge et les bras. Toutes les conditions, globalement, se sont situées dans la plage acceptable (au dessus de 4), sauf dans le cas de la condition A (10 couches KM2 600 + 9 couches FR10 avec des plaques de 1,9 kg) de la phase 1a et de la condition Ninitiale (2,1 kg/m2 KM2 400 (N1), 5,4 kg/m2 Spectra Shield SA−3118 (N3) avec des plaques de 1,4 kg) de la phase 1. Il semble que le volume pose davantage problème aux militaires que la rigidité. Il est modérément aisé, à partir de la densité surfacique, de prévoir le degré d’acceptation par les militaires d’une protection souple, mais il semble exister un autre facteur, non pris en compte dans la mesure de cette densité, qui a autant d’effet sur leur acceptation. Lors de la phase 1, la condition Ninitial a été construite des matériaux superposés N1 et N3 de même dimension. Lors de la phase 1A, les matériaux N1 n’ont pas été changés, et recouvrait le torse au complet, mais les matériaux N3 ont été taillée afin de couvrir seulement la région centrale du torse, laissant les côtés, les aisselles, le bas du torse et la région du cou avec le matériel plus souple N1. En réduisant les caractéristiques de rigidité, de poids et de volume de la protection dans les régions clés, autour des épaules et de la taille, et dans les protections accessoires amovibles, la protection N est passé de carrément inacceptable à nettement acceptable. La coupe et le concept différents du SGPBTM n’ont pas eu d’effet négatif sur les résultats. Les limites des conclusions sont abordées, notamment les participants, la taille de l’échantillon, les conditions d’expérimentation, le caractère limité de l’exposition et les essais. Il y a formulation de recommandations d’ordre général et de recommandations sur la phase 2.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) C−IED; Horizon 0; counter−IED; soft armour; torso armour; ballistic protection; IED; body armour; improvised explosive devices; human factors; areal density; MTBAS; Modular Tactical Body Armour System